DRAFT

ENVIRONMENTAL IMPACT STATEMENT

HORSE DRAW
OIL SHALE RESEARCH TRACT
RIO BLANCO COUNTY, COLORADO

U.S. BUREAU OF MINES
DENVER, COLORADO

prepared by VTN IRVINE, CALIFORNIA

Notice of Withdrawal of Draft Environmental Impact Statement

This is to advise you that the Draft Environmental Impact Statement (DEIS) for Horse Draw Oil Shale Research Tract, Rio Blanco County, Colorado, was prematurely released in August, 1980. The Bureau of Mines has withdrawn the DEIS for further internal review. This DEIS may be resubmitted in the future and you will be advised of any further action on this matter.

U.S. BUREAU OF MINES

HORSE DRAW OIL SHALE RESEARCH TRACT

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Prepared by:

VTN CONSOLIDATED, INC.

August, 1980

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U.S. BUREAU OF MINES
OIL SHALE RESEARCH TRACT
RIO BLANCO COUNTY, COLORADO

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Denver Federal Center
Building 20
Denver, Colorado 80225

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<u>Abstract</u>

This Draft Environmental Impact Statement has been prepared in response to a proposal by the Multi Mineral Corporation to conduct an oil shale research program at the United States Bureau of Mines Oil Shale Mining Environmental Research Facility. The project will include subsurface pyrolysis of oil shale and leaching of residual alumina and soda ash using existing surface and subsurface facilities. The project is located in northwestern Colorado in Rio Blanco County within the Piceance Creek Basin on land managed by the U.S. Bureau of Land Management.

Comments regarding this Draft Environmental Impact Statement must be received by the Technical Project Officer, U.S. Bureau of Mines, by:

OCT 28 1980

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SECTION 1.0

SUMMARY

The Multi Mineral Corporation (MMC) proposes to undertake a 12 month program of oil shale processing, environmental research, and geotechnical test work, utilizing the MMC Integrated In Situ Method of recovery. The U.S. Bureau of Mines (USBM) is considering an agreement for the use of its Oil Shale Mining Environmental Research Facility in the central Piceance Creek Basin, Rio Blanco County, Colorado, for this project. The results of this research program will be used to determine the potential environmental problems involved in recovering the deep oil shale deposits using this process. If successful, this process could substantially benefit the industry by establishing an efficient means of recovery which could be utilized in other areas on commercial scale projects.

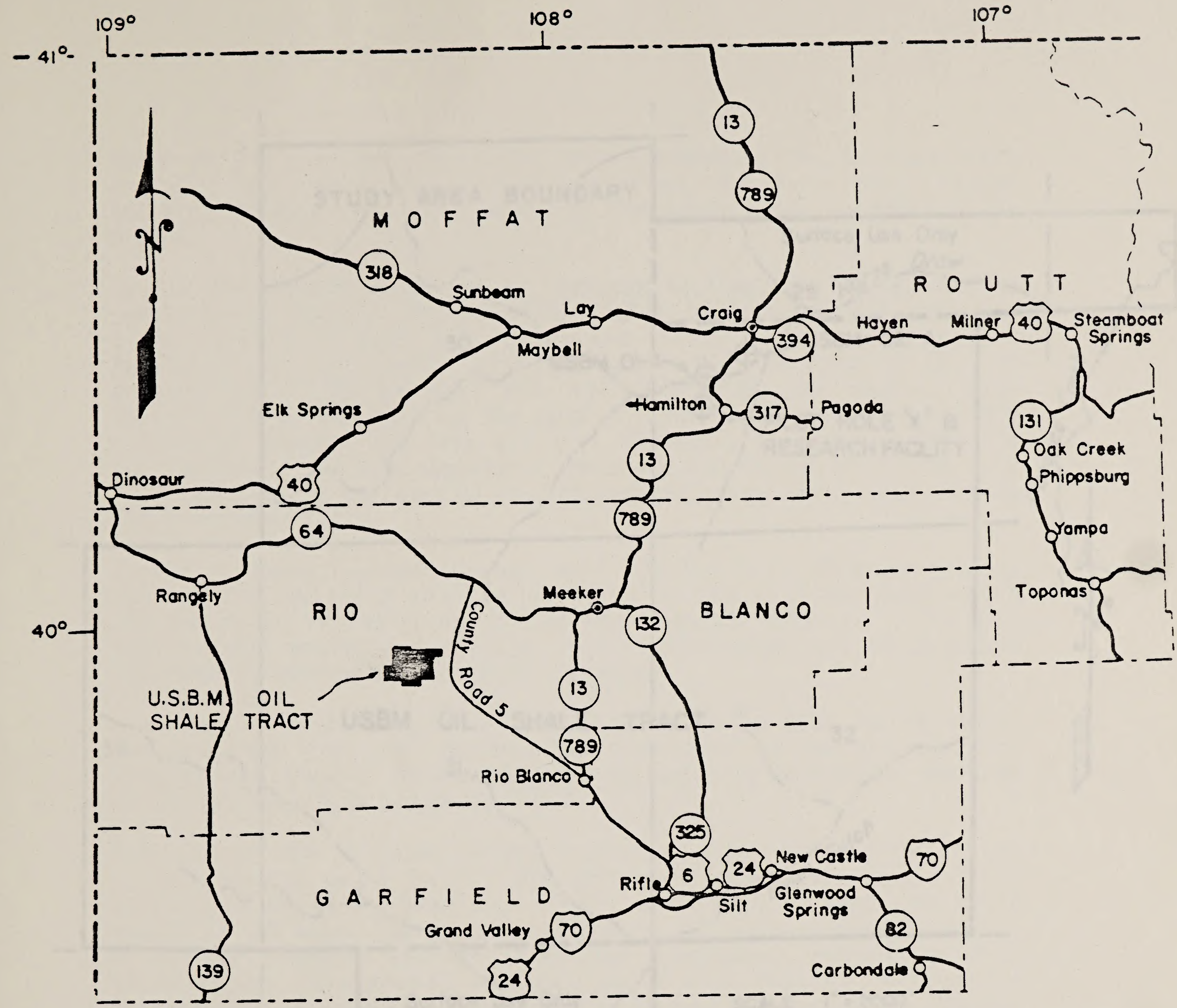
The USBM facility is located in northwestern Colorado on the western slope of the Rocky Mountains at an elevation of 1,900 m (6,320 ft). The 9 ha (22 ac) site is located on Horse Draw, a tributary of Piceance Creek, approximately 2.5 km (1.56 miles) upstream of the confluence of the two drainages. It is approximately 35 km (22 miles) southwest of Meeker near Federal Oil Shale Prototype Lease Tracts C-a and C-b (see Figures 1.0-1 and 1.0-2) in a semi-arid, high plains area, characterized by pinyon-juniper and sagebrush.

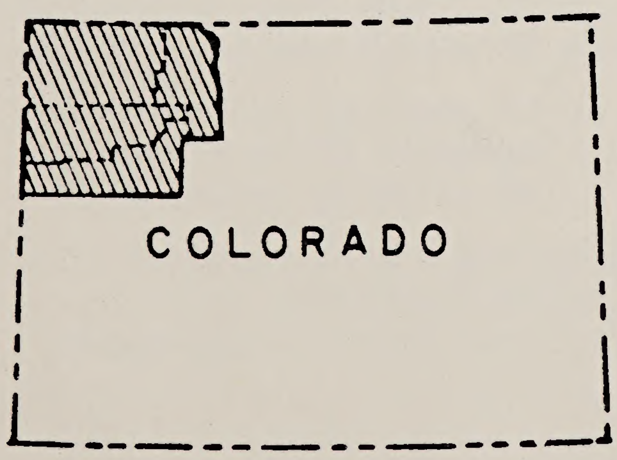
The existing USBM research facility consists of a small-diameter shaft and ancillary surface plant designed to provide access to the deep, thick deposits of oil shale and associated saline minerals (i.e. nahcolite and dawsonite).

Currently Multi Mineral Corporation, under an agreement entered into April 30, 1979 with the U.S. Department of Interior, Bureau of Mines and Bureau of Land Management, is using the USBM research facility to conduct a two-phased research program to obtain mining, environmental and geotechnical test data and bulk samples of nahcolite, oil shale and dawsonite.

During Phase I of the plan, a 5,000-ton sample of 80 percent by weight nahcolite product was obtained. This was accomplished by excavating a test room in a bedded nahcolite horizon on the 1,840 foot level. Phase II included excavation of a 64' x 40' x 100' stope block within a nahcolitedawsonite oil shale horizon at the 2,130 to 2,230 foot level.

The proposed project consists of three phases. The first phase, construction, is anticipated to begin on or about May, 1981, and be completed within 6 months. Site preparation will be minimal due to the utilization of the existing facility. All new construction will





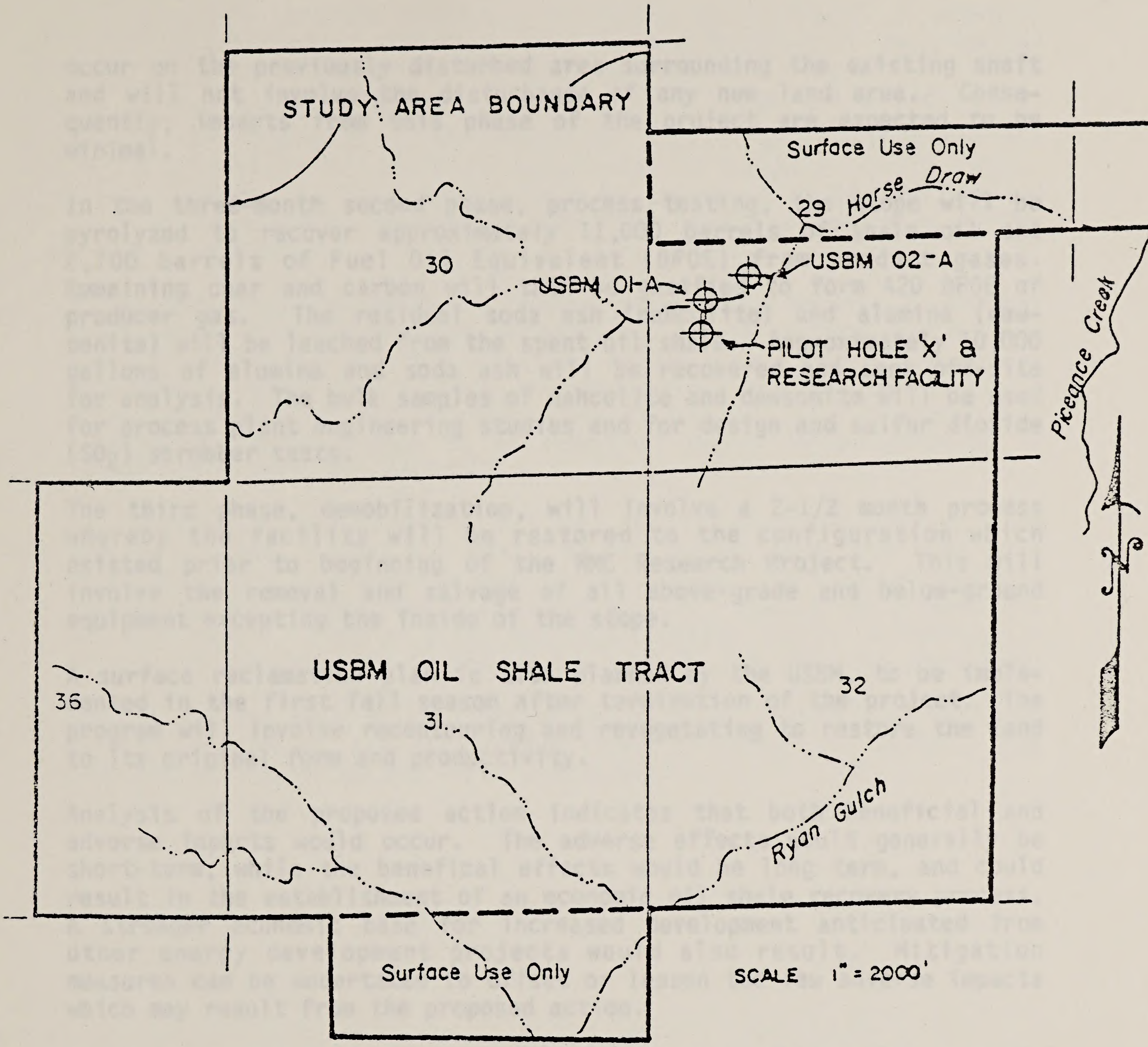
Key Map

0 10 20 miles

SCALE

AREA MAP SHOWING LOCATION
OF USBM OIL SHALE TRACT

FIGURE 1.0-1



USBM OIL SHALE TRACT SHOWING LOCATION OF RESEARCH FACILITY

FIGURE 1.0-2

occur on the previously disturbed area surrounding the existing shaft and will not involve the disturbance of any new land area. Consequently, impacts from this phase of the project are expected to be minimal.

In the three-month second phase, process testing, the stope will be pyrolyzed to recover approximately 11,000 barrels of shale oil and 2,700 barrels of Fuel Oil Equivalent (BFOE) from product gases. Remaining char and carbon will then be gasified to form 420 BFOE of producer gas. The residual soda ash (nahcolite) and alumina (dawsonite) will be leached from the spent oil shale. Approximately 10,000 gallons of alumina and soda ash will be recovered and sent off-site for analysis. The bulk samples of nahcolite and dawsonite will be used for process plant engineering studies and for design and sulfur dioxide (SO_2) scrubber tests.

The third phase, demobilization, will involve a 2-1/2 month process whereby the facility will be restored to the configuration which existed prior to beginning of the MMC Research Project. This will involve the removal and salvage of all above-grade and below-ground equipment excepting the inside of the stope.

A surface reclamation plan is also planned by the USBM, to be implemented in the first fall season after termination of the project. The program will involve recontouring and revegetating to restore the land to its original form and productivity.

Analysis of the proposed action indicates that both beneficial and adverse impacts would occur. The adverse effects would generally be short-term, while the benefical effects would be long term, and could result in the establishment of an economic oil shale recovery process. A stronger economic base for increased development anticipated from other energy development projects would also result. Mitigation measures can be undertaken to offset or lessen the few adverse impacts which may result from the proposed action.

It is recognized that the proposed project would produce certain unavoidable adverse environmental effects including:

- An increase in road kills of deer in the study area due to higher traffic volumes. This is anticipated to be the primary impact on wildlife.
- An increase in air and noise pollution from increased traffic and from equipment emissions. Although these impacts are unavoidable, they are not anticipated to be significant.

- Soil erosion presently occurring as a result of previous activities would continue for the duration of the proposed project and until the land is reclaimed. No other adverse impacts relative to surface hydrology are anticipated.
- An increase in the demand on schools and housing may adversely affect the communities of Rangely, Rifle and/or Meeker. This demand would be created from the anticipated population increase of 225 which would be generated by the project.

Nothwithstanding the adverse effects, significant beneficial effects would accrue from the proposed project. In the short-term, the project would increase the economic activity in the area, from increases in employment, retail and service industry sales, and the tax base. A long-term beneficial effect could occur if the oil shale recovery process being tested proves to be efficient enough to be utilized on larger scale shale oil projects.

In addition to the proposed action, two alternative actions were examined. One alternative would be no action, with the USBM site being preserved for research work in the future. This would result in postponing the reclamation plan indefinitely. The second alternative would also be a no action plan, but would involve timely implementation of the reclamation plan to return the site to its previous condition.

In view of the ability to mitigate the primary adverse environmental effects as well as the anticipated level of beneficial impacts, the proposed action is the preferred alternative.

SECTION 2.0

PURPOSE

2.1 Introduction

Pursuant to Title 40, Protection of the Environment (CFR), Part 1500 to Part 1508, this Environmental Impact Statement (EIS) has been prepared by the United States Department of the Interior, Bureau of Mines (USBM), and VTN Consolidated, Inc. (VTN), its environmental consultant.

The EIS evaluates a proposed 12 month program of oil shale in situ processing, environmental research, and geotechnical test work to be conducted by Multi Mineral Corporation (MMC). The USBM has agreed to the use of its Oil Shale Mining Environmental Research Facility in central Piceance Creek Basin, Rio Blanco County, Colorado, to accomplish this project.

In accordance with the provisions of 40 CFR 1501.7, USBM held a scoping meeting for the EIS on November 8, 1979. The purpose of the meeting was to solicit agency and public comments to identify environmental issues to be addressed in the EIS. No major concerns regarding this project were identified at that time. However, the issue was raised relative to the cumulative socioeconomic effects of this and other projects. There are many oil shale and coal recovery mining projects proposed or in progress in the northwestern Colorado area, and there is a concern regarding the overall impacts of these projects (see 5.8.7). Documentation of the scoping meeting and a list of attendees are included in Table 2.0-1.

2.2 Previous Environmental Documentation

The BLM completed an Environmental Analysis Report (EAR) for the research facility on April 19, 1976. An intra-agency Cooperative Research Agreement (USBM Agreement No. 14-09-0070-662) between USBM and BLM became effective on October 4, 1976, and authorized construction of a Research Facility at the Horse Draw site "for use by the Bureau of Mines in testing, developing and demonstrating new or improved underground methods of mining oil shale and associated minerals and extracting shale oil by modified in-situ methods."

In 1978, the USBM prepared a Draft EIS which analyzed the impacts of their proposed research program. The Draft EIS and the EAR (CO-010-6-130) were reviewed by staff specialists of the BLM's White River Resource Area. However, the documents were not finalized.

Late in 1978, the USBM was authorized to solicit outside proposals from other government agencies and industry for research to be conducted at

TABLE 2.0-1

PARTICIPANTS OF THE
SCOPING MEETING FOR THE EIS ON MULTI MINERAL
PROCESSING RESEARCH PROGRAM AT THE HORSE DRAW FACILITY
(Meeker, Colorado - November 8, 1979)

	Name	Address	Affiliation
1.	Thomas Boyd	P.O. 928, Meeker, CO	BLM
2.	George Long	P.O. 928, Meeker, CO	BLM
3.	John Mann	P.O. 928, Meeker, CO	BLM
4.	Bill Daniels	1600 Broadway, Denver, CO	BLM
5.	Roy Trujillo	Grand Junction, CO	Mine Safety & Health Admin.
6.	Collin Galloway	Grand Junction, CO	Mine Safety & Health Admin.
7.	John E. Unger, Jr.	Rifle, CO	Cleveland Cliffs Iron
8.	Bob Elderkin	Grand Junction, CO	Area Oil Shale Off.
9.	W. Jack Clark	Piceance Creek Rt., Rifle, CO 81650	Rio Blanco Oil Shale Company
10.	Barry Dupire	Meeker, CO	Div. of Wildlife
11.	Terry Loyer	Craig, CO	BLM
12.	Frank Welder	Meeker, CO	USGS, WRD
13.	Bob Tobin	Meeker, CO	USGS, WRD
14.	Curt Smith	P.O. 920, Meeker, CO	BLM
15.	Steve Utter	Denver, CO	Bureau of Mines
16.	Bob Bolmer	Denver, CO	Bureau of Mines
17.	C.G. Mattsson	2301 Campus, Irvine, CA	VTN Consolidated
18.	J.R. Lane	2301 Campus, Irvine, CA	VTN Consolidated
19.	E.B. Sacra	Houston, TX	Multi Mineral Corp.
20.	Ben Weichman	Houston, TX	Multi Mineral Corp.
21.	Jim Meredith	Denver, CO	Multi Mineral Corp.
22.	Jim Cook	Box 720, Meeker, CO	Meeker Herald
23.	Glenn Payne	Box 720, Meeker, CO	Rio Blanco County Planning Office

the research facility. On April 30, 1979, a Memorandum of Agreement between USBM, BLM, and Multi Mineral Corporation (MMC), of Houston, Texas, was signed. Under this agreement, MMC was granted permission to conduct a 2 year mining research program at the existing facility.

In addition to the environmental documentation, Special Land Use Permits C-22671, C-22672, and S-CO-101-76-7 have been issued by the BLM to USBM for initial core drilling and construction of an access road to the project site.

SECTION 3.0

ALTERNATIVES INCLUDING PROPOSED ACTION

3.1 Existing Site Facilities and Services

The USBM has constructed an Oil Shale Mining Environmental Research Facility in central Piceance Creek Basin of northwestern Colorado. The Research Facility site is located approximately 2.5 kilometers (1.56 miles) up Horse Draw, a tributary of Piceance Creek approximately 35 kilometers (22 miles) southwest of Meeker, Colorado.

The USBM in consultation with the U.S. Geological Survey (USGS) selected the Horse Draw site from an array of four potential sites. Initially, cores were extracted from Fault Draw, analyzed, and found to be unsuitable for the proposed project. Two core holes (USBM 01-A and 02-A) were drilled in the Horse Draw area between November 1975 and January 1976. The site was found suitable and the decision was made to use the Horse Draw site for the Research Facility, contingent upon the availability of the land.

The USBM Oil Shale Mining Environmental Research Facility is located on a tract of land in Rio Blanco County, Colorado, described in Intra-Agency Cooperative Research Agreement No. 14-09-0070-662 between the U.S. Department of the Interior Bureau of Mines and the U.S. Department of the Interior Bureau of Land Management effective October 8, 1976. The tract includes all the National Resource Lands described below and shown on Figures 1.0-1 and 1.0-2.

Sixth Principal Meridian, Rio Blanco County, Colorado

T. 1 S., R. 97 W.:	Section 28 --	SW 1/4 NW 1/4
	Section 29 --	S 1/2 N 1/2, W 1/2 SE 1/4, SW 1/4
	Section 30 --	All
	Section 31 --	All
	Section 32 --	W 1/2 E 1/2, W 1/2
T. 1 S., R. 98 W.:	Section 36 --	E 1/2
T. 2 S., R. 97 W.:	Section 6 --	Lots 1, 2 and 3

The tract encompasses approximately 1,070 ha (2,643 ac), of which 940 ha (2,323 ac) are designated for surface and mining use and 130 ha (320 ac) are designated for surface use only. The Research Facility site comprises approximately 9 ha (22 ac) located in the SW 1/4 of Section 29, T. 1 S., R. 97 W.

Special Land Use Permits C-22672 and S-CO-101-76-7 were issued by the Bureau of Land Management (USBLM) to USBM for initial core drilling and construction of an access road to the Horse Draw site. On March 10, 1976, USBM filed an amendment to SLUP C-22672 which allowed drilling of four additional core holes.

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Initial USBM plans called for development of an experimental mine to facilitate full-scale testing, evaluation and demonstration of several promising underground mining methods. However, authority to conduct oil shale mining productivity research was transferred to the U.S. Department of Energy (DOE) in 1977. The Bureau of Mines retained authority to conduct oil shale mining environmental research at its Research Facility.

Research and test work will be conducted from a small shaft which was bored and cased between March 1977 and January 1978. It was blind bored 3 meters (10 feet) in diameter to a depth of 723 meters (2,371 ft) and subsequently lined to a depth of 717 meters (2,352 ft) with 2.4-meter (8-ft) I.D. steel casing. The lower 488 meters (1,600 ft) of the shaft penetrate virtually the full thickness of oil shale and accessory minerals in the Parachute Creek member of the Green River Formation. The original purpose of this shaft was to permit bulk sampling of deep oil shale deposits for processing tests and, ultimately, to serve as an exhaust airway and emergency escapeway for a proposed demonstration mine. However, when authority for oil shale mining research was transferred to DOE, the current mining environmental research and geotechnical test programs were developed to maximize benefits from the existing Research Facility. Subsequently, the surface plant consisting of a headframe, hoist house, offices, shop and dry house was erected and the shaft equipped with hoisting, ventilation and service systems. A plan of the Research Facility is shown in Figure 3.1-1.

3.2 Current Mining Activity

Multi Mineral Corporation entered an agreement on April 30, 1979 with the U.S. Department of the Interior's Bureau of Mines and Bureau of Land Management for using the experimental mining facilities on Horse Draw, Rio Blanco County, Colorado. These facilities were used for research in oil shale mining, and health and safety hazards, for mining environmental research, for obtaining information on geology, hydrology, and mineral resources, and for obtaining bulk samples of oil

USBLM completed an Environmental Analysis Report of the proposed project on April 19, 1976. An Intra-agency Cooperative Research Agreement (USBM Agreement No. 14-09-0070-6621) between USBM and USBLM became effective on October 8, 1976 and authorized construction of the Research Facility at the Horse Draw site "for use by the Bureau of Mines in testing, developing and demonstrating new or improved underground methods of mining oil shale and associated minerals and extracting shale oil by modified in situ methods."

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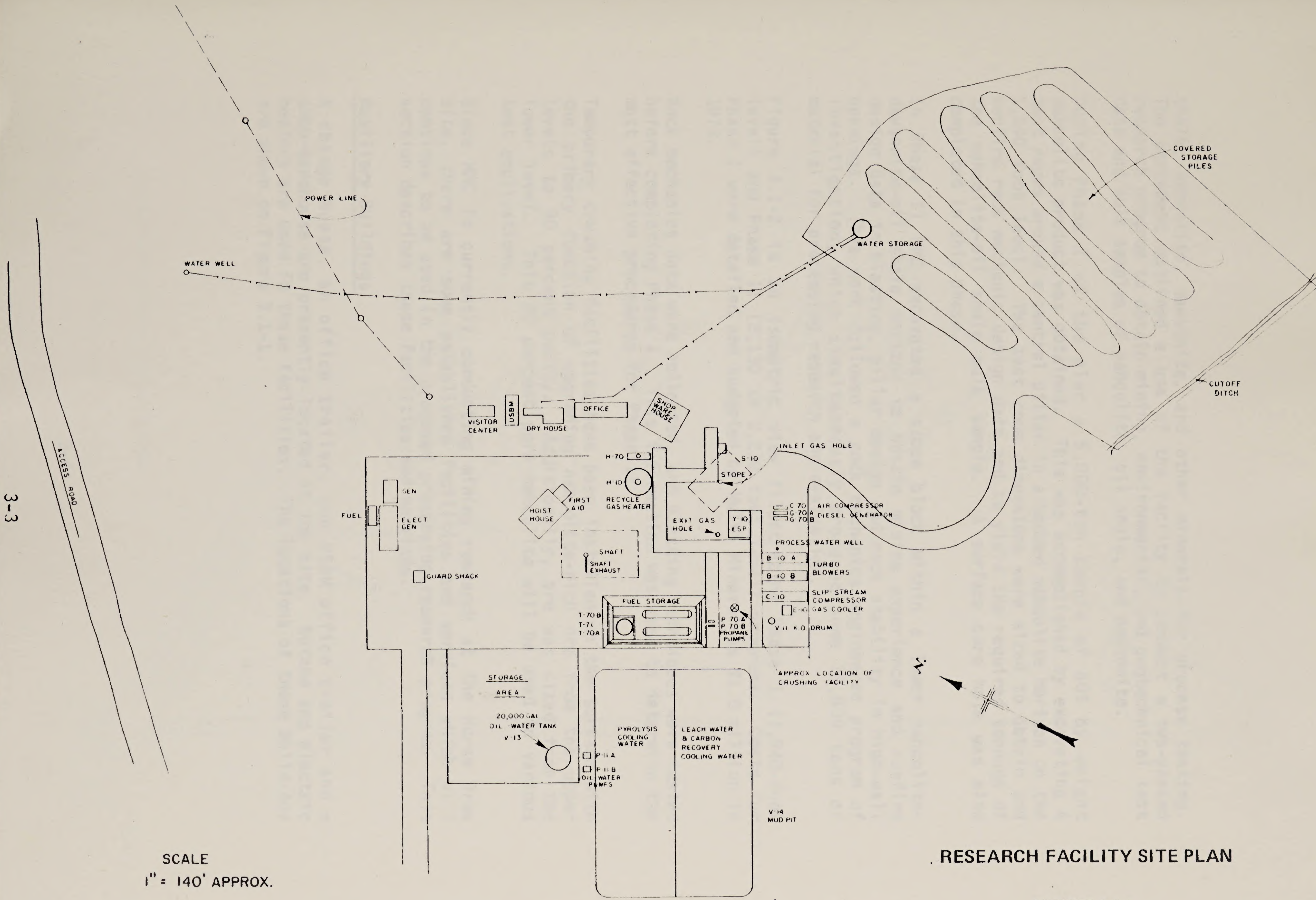


SCALE
1" = 140' APPROX.

RESEARCH FACILITY SITE PLAN

FIGURE 3.1-1

shale, nahcolite, dawsonite, and other minerals for process testing. The agreement outlined a use of the faciity to conduct a two-phased research program to obtain mining, environmental, and geotechnical test data and bulk samples of nahcolite, oil shale, and dawsonite.

During Phase I of the plan a 5,000-ton sample of 80% by weight nahcolite product was obtained. This was accomplished by excavating 4 test rooms around a central pillar in a bedded nahcolite horizon on the 1,840 foot level. The test room dimensions were sized to obtain and confirm rock mechanic design data and to yield the required tonnage of the nahcolite-oil shale bulk sample. A surface core hole was also completed in this phase.

In Phase II MMC excavated a stope block within a lower nahcolite-dawsonite-oil shale horizon to obtain mining experience and confirm design data in blasting, pillar design and rock stability in high-wall openings. This work followed a rock mechanics engineered program of investigation, which simultaneously produced some 15,000 tons of material for processing research and evaluation.

Figure 3.1-2 is an isometric view illustrating Phase I (1,840-foot level) and Phase II (2,130 to 2,230 foot level) programs. Costs for Phase I were detailed and budgeted by Multi Mineral as $1.8 million in 1979.

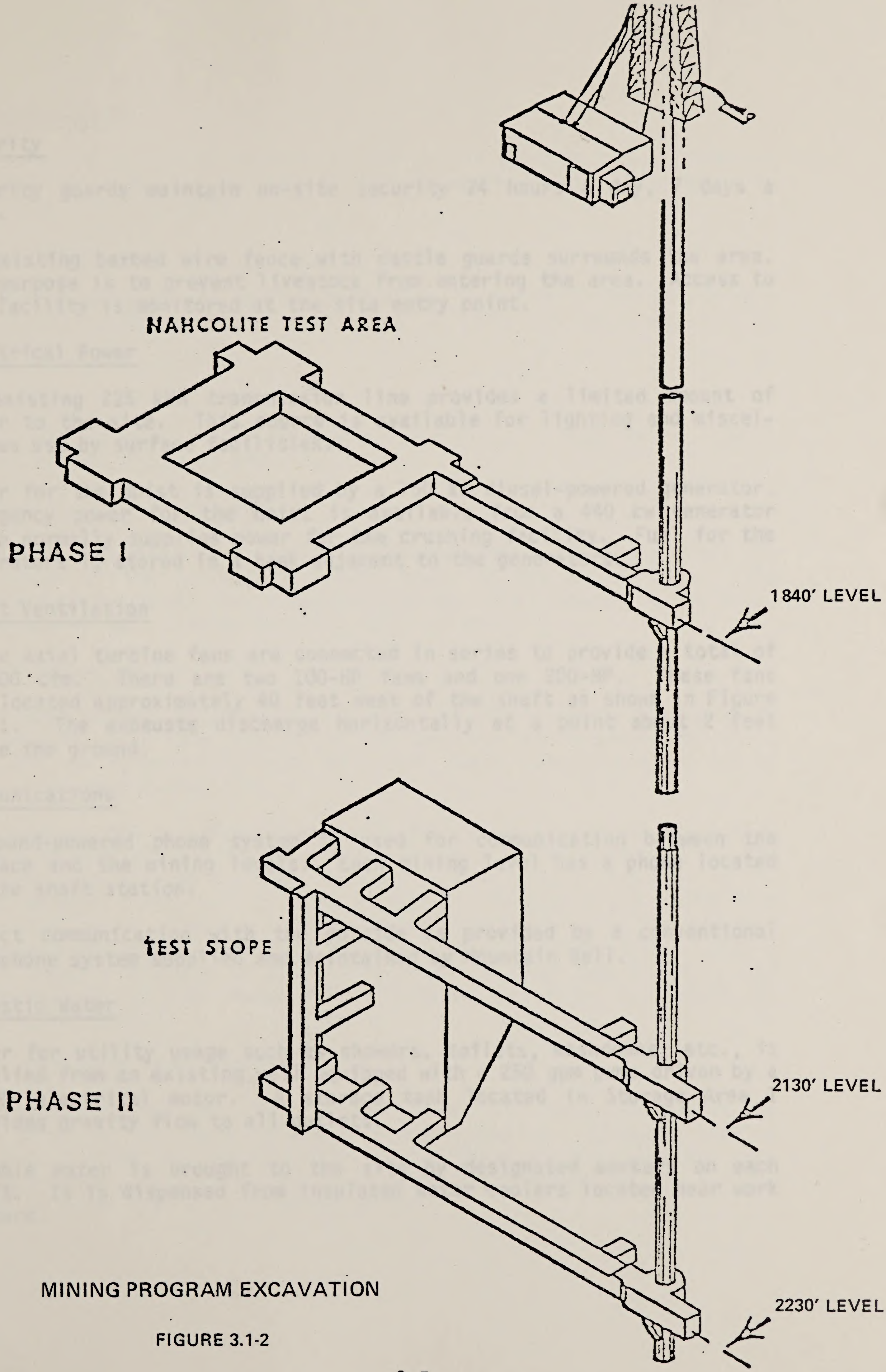
Rock mechanics data were collected, and blasting techniques were tested before completing Phase I. This information was used to determine the most effective procedures for Phase II.

Temporary crushing facilities have been installed on the surface with the primary function of upgrading nahcolite-rich ore from the upper levels to 80 percent purity. Additionally, ore was sized from the lower level. This 80 percent pure nahcolite will be used in various test applications.

Since MMC is currently conducting mining research at the Horse Draw site, there are some established facilities and services which will continue to be used in the proposed processing research program. This section describes these facilities and services.

<u>Auxiliary Buildings</u>

A change house, an office trailer, one USBM office trailer and a shop-warehouse are presently located at the site. Butane and electric heaters are used in these facilities. The locations of these buildings are shown on Figure 3.1-1.



MINING PROGRAM EXCAVATION

FIGURE 3.1-2

Security

Security guards maintain on-site security 24 hours a day, 7 days a week.

An existing barbed wire fence with cattle guards surrounds the area. Its purpose is to prevent livestock from entering the area. Access to the facility is monitored at the site entry point.

Electrical Power

An existing 225 KVA transmission line provides a limited amount of power to the site. This source is available for lighting and miscellaneous use by surface facilities.

Power for the hoist is supplied by a 750 kw diesel-powered generator. Emergency power for the hoist is available from a 440 kw generator which normally supplies power for the crushing facility. Fuel for the generators is stored in a tank adjacent to the generators.

Shaft Ventilation

Three axial turbine fans are connected in series to provide a total of 35,000 cfm. There are two 100-HP fans and one 200-HP. These fans are located approximately 40 feet west of the shaft as shown in Figure 3.1-1. The exhausts discharge horizontally at a point about 2 feet above the ground.

Communications

A sound-powered phone system is used for communication between the surface and the mining levels. Each mining level has a phone located in the shaft station.

Direct communication with the outside is provided by a conventional telephone system supplied and maintained by Mountain Bell.

Domestic Water

Water for utility usage such as showers, toilets, washdowns, etc., is supplied from an existing well equipped with a 250 gpm pump driven by a 20 HP electrical motor. A storage tank located in Storage Area 1 provides gravity flow to all outlets.

Potable water is brought to the site by designated workers on each shift. It is dispensed from insulated water coolers located near work centers.

Sanitary Sewage

The existing system utilizes a 10,000 gallon holding tank. Contract services provide for the pickup and disposal of the effluent. No discharge occurs on-site.

Trash Disposal

Trash from the mine and surface operations is stored in containers near the hoist house. Pickup and disposal services are supplied by contract.

First Aid

First aid and mine rescue equipment, conforming to applicable regulations, are available at the site.

Air Quality Monitoring Station

An air quality monitoring station is located inside the fence along the west edge of the facility and just south of the access road. The device monitors total suspended particulates (TSP) levels at the site. Operation of this station began in July, 1979.

3.3 Proposed Action

The intent of the proposed Multi Mineral oil shale research program is to generate sound data from which the technical and economic feasibility, and environmental effects of a full scale modular project can be more accurately determined.

The proposed MMC research program will follow the successful completion of the mining activities which are currently being conducted at the site. It will utilize the stope created in that program for testing the Multi Mineral Integrated In Situ Method of processing oil shale from the saline zone. There are three phases of activities in the proposed program--construction, process testing, and demobilization. Table 3.1-1 shows a schedule of activities within each of the phases. Upon completion of the last phase, MMC will cease operations and return the facility to USBM.

3.3.1 Proposed New Construction

This phase consists of all activities which will be conducted at the site prior to the start of actual process testing. Although some of these activities may not actually be classified as construction, they are presented here for continuity. Construction activities are anticipated to occur over a 6-1/2 month period.

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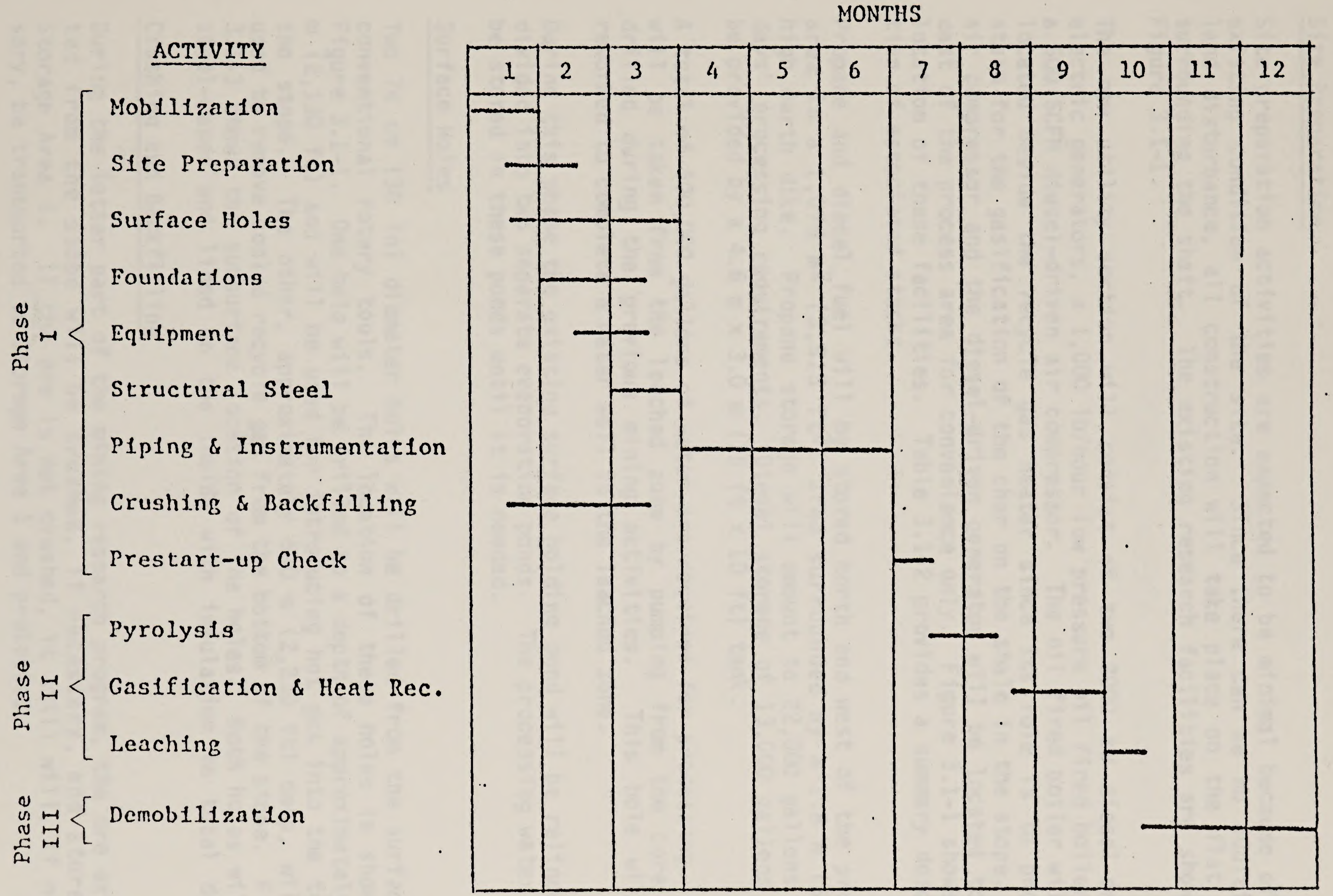


PRELIMINARY SCHEDULE OF ACTIVITIES

TABLE 3.1-1

Site Preparation

Site preparation activities are expected to be minimal because of the existing condition of the site. Since there can be no additional land disturbance, all construction will take place on the flat area surrounding the shaft. The existing research facilities are shown on Figure 3.1-1.

The new utility section will consist of two 2000 kw diesel-driven electric generators, a 1,000 lb/hour low pressure oil fired boiler and a 600 SCFM diesel-driven air compressor. The oil fired boiler will be located beside the recycle gas heater since its role is to provide steam for the gasification of the char on the shale in the stope. The air compressor and the diesel-driven generator will be located to the east of the process area for convenience only. Figure 3.1-1 shows the location of these facilities. Table 3.1-2 provides a summary description of associated stacks.

Propane and diesel fuel will be stored north and west of the process area in a 1,076 m^2 (3,515 ft^2) area surrounded by a 1.8 m (6 ft) high earth dike. Propane storage will amount to 22,000 gallons or 5 days' processing requirements. Diesel storage of 13,000 gallons will be provided by a 4.6 m x 3.0 m (15 ft x 10 ft) tank.

A total of 500,000 gallons of water are required for processing. This will be taken from the leached zone by pumping from the core hole drilled during the previous mining activities. This hole will be reworked to complete a water well in the leached zone.

During this phase the existing surface holding pond will be relined and divided into two separate evaporation ponds. The processing water will be stored in these ponds until it is needed.

Surface Holes

Two 76 cm (30 in) diameter holes will be drilled from the surface by conventional rotary tools. The location of these holes is shown on Figure 3.1-1. One hole will be drilled to a depth of approximately 649 m (2,130 ft) and will be used for introducing hot gas into the top of the stope. The other, approximately 680 m (2,230 ft) deep, will be used to remove cooled recycle gas from the bottom of the stope. Figure 3.1-3 shows the subsurface location of the holes. Both holes will be steel-cased and lined on the inside with insulation to total depth.

Crushing and Backfilling

During the latter part of the mining research program, the ore extracted from the stope will be crushed, if necessary, and stored in Storage Area 1. If the ore is not crushed, it still will, if necessary, be transported to Storage Area 1 and protected.

TABLE 3.1-2

STACK DESCRIPTION

	Stack Height	Diameter	Temperature	SCFM Volume
Boiler	20'	1'	800°F	600
Recycle Gas Heater				
Pyrolysis	30'	3'	400°F	380,000
Gasification	30'	3'	400°F	150,000

Ore from Storage Area 1 will be transported to the crusher stockpile by a front-end loader and dump truck. From the stockpile, the ore will be fed to a 30 TPH Hazemag impactor crusher which will operate 24 hours per day, seven days per week until the entire 14,000 tons of rock has been crushed. After crushing, the sized ore will be fed onto a conveyor which will move it to the shaft for introduction into the stope by reversing the extraction method.

Following excavation of the stopes and retort, approximately 20,000 tons of ore were stockpiled in Storage Area 1. Approximately 6,000 tons of this material cannot be backfilled into the stope due to the swelling of the extracted materials. This excess will remain in storage, covered with reinforced plastic sheeting, and ditched to prevent contact with surface water.

Figure 3.1-1 shows the location of the temporary crushing facility. It will reduce the dawsonitic oil shale extracted from the bottom of the stope to minus 20 cm (8 in.) size. The facility will be made up of semi-portable units for ease of transportability. Basically, it will consist of a feeder and scalping grizzly discharging to a flow-bar impactor-type crusher with the crushed product being fed to a triple deck screen. This screen is used for sizing and recycling. Transfer points will be hooded and connected to a negative pressure system which will vent to a baghouse. This dust collection system will reduce the particulate emissions. The capacity of this facility will be approximately 30 tons per hour (TPH).

Stope Sealing

Bulkheads will be installed during the latter part of construction at eight locations as follows (see Figure 3.1-3 for locations):

1. Upper stope drift 649 m (2,130 ft) level adjacent to the stope (three places)

2. Upper sub drift adjacent to the stope

3. Lower sub drift adjacent to the stope

4. Lower sub drift 680 m (2,230 ft) level adjacent to stope (three places)

These bulkheads, which seal the stope from the rest of the mine, will consist of steel plates secured in place by the use of reinforced concrete.

3.3.2 Process Testing

Following all construction activities, process testing will be initiated. Process testing is expected to take 2-1/2 months. The oil shale

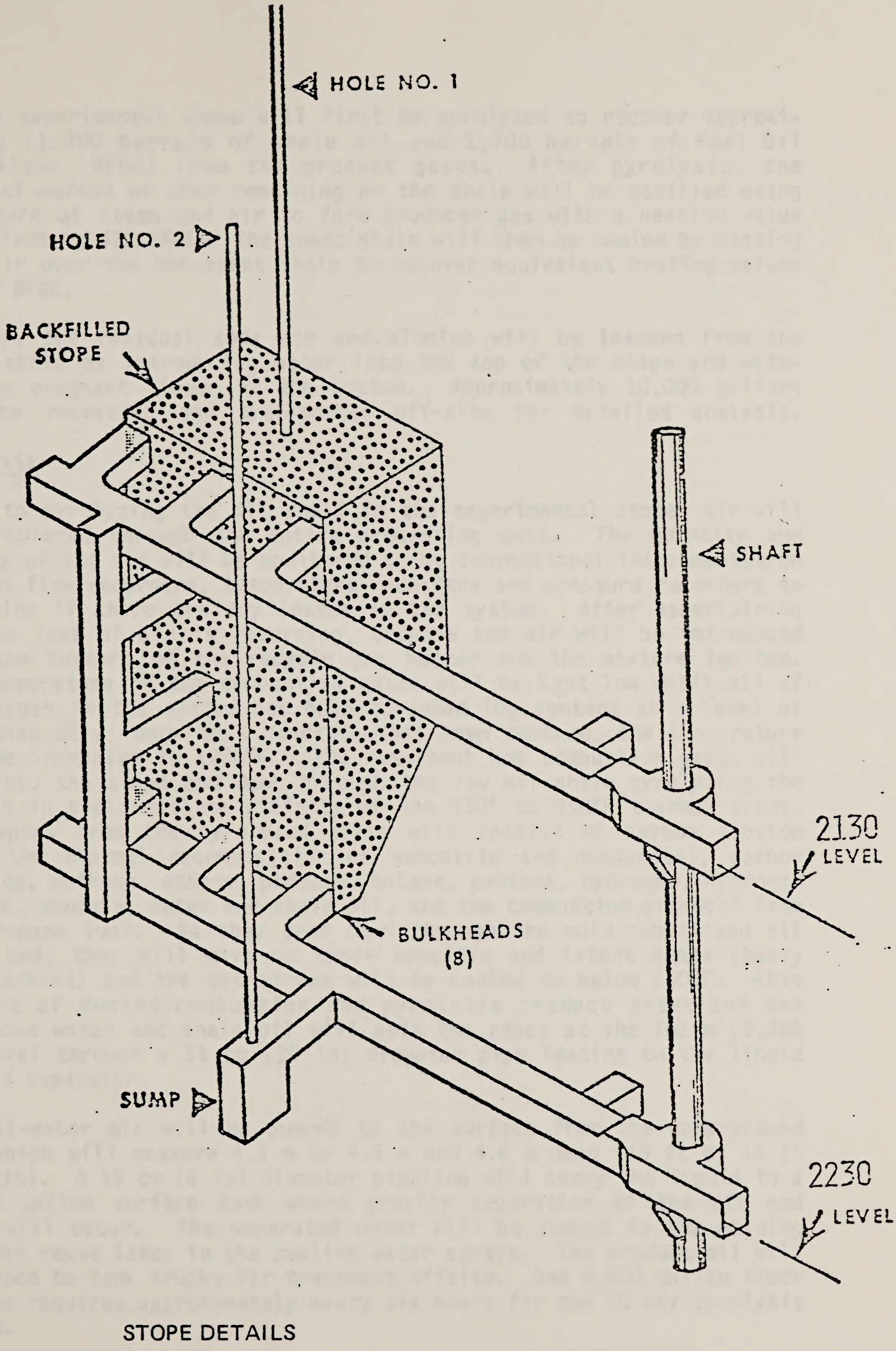

HOLE NO. 1
HOLE NO. 2
BACKFILLED STOPE
SHAFT
2130 LEVEL
BULKHEADS (8)
SUMP
2230 LEVEL
STOPE DETAILS

FIGURE 3.1-3

in the experimental stope will first be pyrolyzed to recover approximately 11,000 barrels of shale oil and 2,700 barrels of Fuel Oil Equivalent (BFOE) from the product gases. After pyrolysis, the residual carbon or char remaining on the shale will be gasified using a mixture of steam and air to form producer gas with a heating value equivalent to 420 BFOE. The spent shale will then be cooled by passing cold air over the hot spent shale to recover equivalent heating values of 880 BFOE.

Finally, the residual soda ash and alumina will be leached from the spent shale by introducing water into the top of the stope and withdrawing pregnant liquor at the bottom. Approximately 10,000 gallons will be recovered and transported off-site for detailed analysis.

Pyrolysis

Prior to pyrolyzing the oil shale in the experimental stope, air will be circulated through the entire processing unit. The quantity and quality of the air will be monitored using conventional instrumentation such as flow recorders, temperature recorders and pressure recorders to determine if there are any losses in the system. After ascertaining that no loss of air is occurring, propane and air will be introduced into the burners of the recycle gas heater and the mixture ignited. The temperature of the combustion gases will be kept low until all of the oxygen in the system has been consumed (O_2 content at a level of less than 2%). Once this condition has been reached, the temperature will be increased to 1200°F. The resultant hot combustion gases will flow into the stope and down through the raw oil shale pyrolyzing the kerogen in the immediate vicinity of the 650° to 850°F thermal front. The vapors from the pyrolyzed shale will consist of carbon dioxide (from the thermal decomposition of nahcolite and dawsonite), carbon monoxide, methane, ethane, propane, butane, pentane, hydrogen, hydrogen sulfide, ammonia, water and shale oil, and the combustion products from the propane fuel. As they pass down through the cold rubbilized oil shale bed, they will give up their specific and latent heats (heavy hydrocarbons) and the gas stream will be cooled to below 200°F. This mixture of cooled combustion and pyrolysis product gases and the condensed water and shale oil will exit the stope at the 701 m (2,300 ft) level through a 51 cm (20 in) diameter pipe leading to the liquid and gas separator.

The oil-water mix will be pumped to the surface from the underground sump which will measure 4.6 m by 4.6 m and 4.6 m deep (15 ft by 15 ft by 15 ft). A 15 cm (6 in) diameter pipeline will carry the liquid to a 20,000 gallon surface tank where gravity separation of the oil and water will occur. The separated water will be pumped to the holding pond for reuse later in the cooling water sprays. The product oil will be pumped to tank trucks for transport offsite. One 6,000 gallon truck will be required approximately every six hours for the 20 day pyrolysis period.

The cooled product gases will be separated from the liquids in the sump and moved to the surface via an 18-inch diameter pipe into the electrostatic precipitator (ESP). The ESP will remove any oil mist and shale fines from the gas stream. The gases will then to two turboblowers, boosting the pressure from -4 psig to 15 psig. A small slipstream (approximately 100 SCFM) will be run to a compressor to determine the amount of light condensibles present. After being compressed, the slipstream will be cooled by an air cooled heat exchanger to condense the light hydrocarbons (oil) and the water present. The main recycle gas stream from the turbo-blowers will be routed either to the knock-out drum to remove any condensed liquids or straight to the furnace depending on the amount of condensibles present.

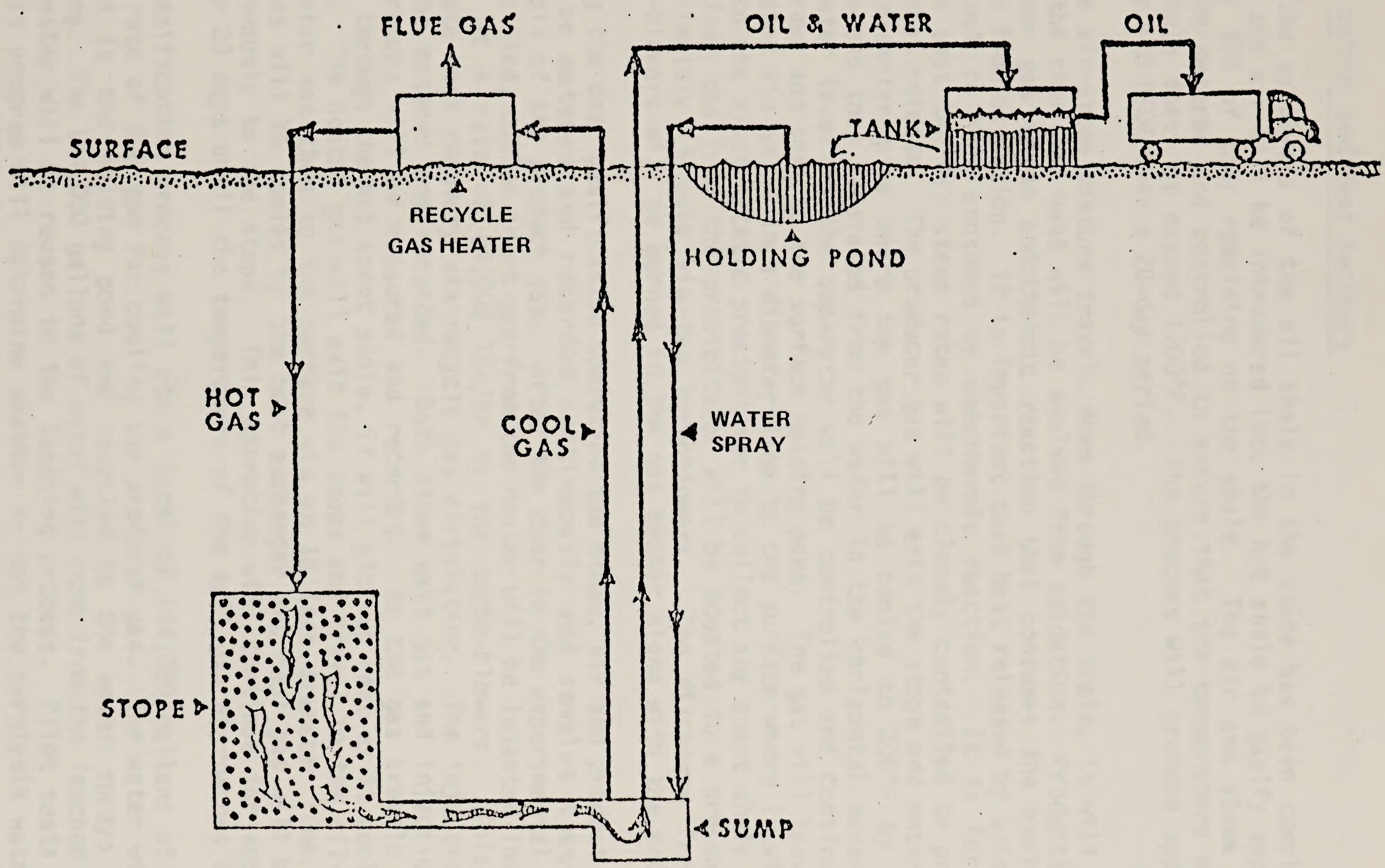
In the furnace the gas will be mixed with sufficient propane so that a temperature of 1200°F will be obtained when combusted. Propane will be required to provide most of the fuel requirements for the first week, after which the products from pyrolysis should be sufficient for a substantial portion, if not all, of the heat input. For the purpose of a "worst case" analysis, the rates given assume that all the gases would be burned over a 20 day period.

For the last six days of the pyrolysis, the shale in the bottom of the stope will be heated to a point where the temperature of the existing gas stream is greater than 200°F. At this time a water spray will be required to cool the gas. Water will be pumped from the holding pond at the maximum rate of about 250,000 lbs/hr (500 gpm) to the water sprays in the exit gas line at the bottom of the stope. The oil-water mix will still be pumped to the surface tank with the separated water being pumped off the bottom of the (20,000 gallon) tank to the holding pond. Due to the large volume of water involved, there may be insufficient time for complete separation of the oil and water. If incomplete separation does occur, some oil may be released to the holding pond. This oil would be contained in a small part of the pond and be pumped back to the storage tank by a skimmer after separation. The water will be reused with a 4 hour capacity required. Pyrolysis will use approximately 100,000 gallons of water. The retorting of the shale is expected to generate approximately 80,000 gallons of water from the shale with the remaining 20,000 gallons being withdrawn from the Leached Zone.

Pyrolysis front movement will be monitored by thermocouples in two thermowells 180° apart and located approximately 40 feet from one another.

The operation of the equipment will be monitored by a gas chromatograph and other instrumentation.

Figure 3.1-4 is a generalized schematic of the pyrolysis process. Table 3.1-3 presents an equipment list for the process.



PYROLYSIS PROCESS SCHEMATIC

FIGURE 3.1-4

Gasification and Heat Recovery

Once the pyrolysis of the oil shale in the stope has been completed, steam and air will be introduced into the hot shale to gasify approximately 50% of char remaining on the shale. The air and steam rates will be metered and controlled to assure that the temperature of the hot shale does not exceed 1200°F. The process will produce approximately 420 BFOE over a 20-day period.

As the air-steam mixture travels down through the shale, it will react with the char and heat will be evolved from oxidation. Production of producer gas is an endothermic reaction that consumes the heat generated from oxidation. It is important that heat released by oxidation be equal to heat consumed by endothermic reaction. It is for this reason that the air steam rates will be closely controlled to produce zero heat release. The producer gas will exit the stope and enter a 20 inch diameter pipe where the gas will be cooled to 200°F by water sprays and then separated from the water in the horizontal separator. The water level in the separator will be controlled and continuously withdrawn and sent to the surface holding pond. The gas will leave the separator via an 18 inch diameter line to the surface where it will be sent to the electrostatic precipitator to collect any spent shale dust. The clean gas from the precipitator will be boosted to a pressure of approximately 15 psig via two turboblowers. The discharge from the turbo-blowers will be burned in the gas heater along with the propane.

During the char gasification operation the steam, air and product gases will be metered and recorded continuously and samples taken for analysis of the product gas. After the char in the experimental stope is gasified, cooled inert gas from the heater will be injected into the stope at a rate of 84,000 lbs/hr by the turbo-blowers. This will simulate heat recovery via recycle gas circulation. The injection gas will be metered and recorded. Both stope exit gas and injection gas temperature will be measured and recorded. As the gas travels downward, through the hot spent shale, it will pick up heat as it cools the shale. The heated gas will exit the stope and travel to the oil-water separator and then to the surface via an 18 inch diameter line. The hot gas will be cooled by the heat exchanger and cool gas will be fed continuously to the stope. This operation will continue for approximately 20 days until the temperature of the exit gas approaches 200°F.

The gasification process will use a total of 144,000 gallons of water at a rate of 500 gpm for cooling the producer gas. The water will be stored in the holding pond and recycled to the water sprays after cooling. The 144,000 gallons of water will come from the leached zone. This water will be reused in the leaching process. Pilot tests prior to this program will determine whether or not the pyrolysis water can be reused in this step.

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Table 3.1-3 includes the equipment list for carbon and heat recovery. Figure 3.1-5 is a general schematic for this step.

Leaching

Once the spent shale in the stope has cooled, approximately 60 gallons per minute of 60°F barren leach water will be introduced into the top of the stope through a 3 inch line. This line will be connected to wide-angle spray nozzles which are positioned above the spent shale. The leach water will percolate through the spent shale and dissolve the chi form alumina and soda ash in the shale. The pregnant liquor will exit the bottom of the stope and flow to the underground sump. This sump will allow control of surges in the system. Liquor from the sump will be reintroduced into the top of the stope through the spray nozzles. The recycle operation will be continued until the liquor reaches approximately 12% soda ash by weight. When this occurs, 10,000 gallons will be pumped to the surface for storage in two 6,000 gallon truck-mounted tanks. This liquor will be sent to equipment manufacturers to develop process equipment.

The temperature and flow rate of the leach water will be controlled and recorded by conventional instrumentation. The barren and pregnant liquors will be analyzed for alumina, silica and soda ash in order to determine leaching efficiencies.

The leaching step will require a total of 400,000 gallons of water. This supply of water will be taken from the water stored in the surface holding pond. After the leaching step is completed, approximately 340,000 gallons will be returned to the surface holding pond with about 50,000 gallons remaining in the stope as interstitial water.

Table 3.1-4 is an equipment list for this step. Figure 3.1-6 presents a generalized schematic of the leaching process.

3.3.3 Demobilization

After the completion of the process testing phase, a 2-1/2 month demobilization phase will begin. This will restore the site to the general condition which existed prior to the beginning of the processing research program.

Vessels, pumps, gas compressors, generators, air compressors, furnace, boiler, precipitator, propane and diesel storage tanks will be removed from their foundations. They will be tagged and crated as necessary for shipment. All of the above-grade equipment foundations will be removed and the area levelled.

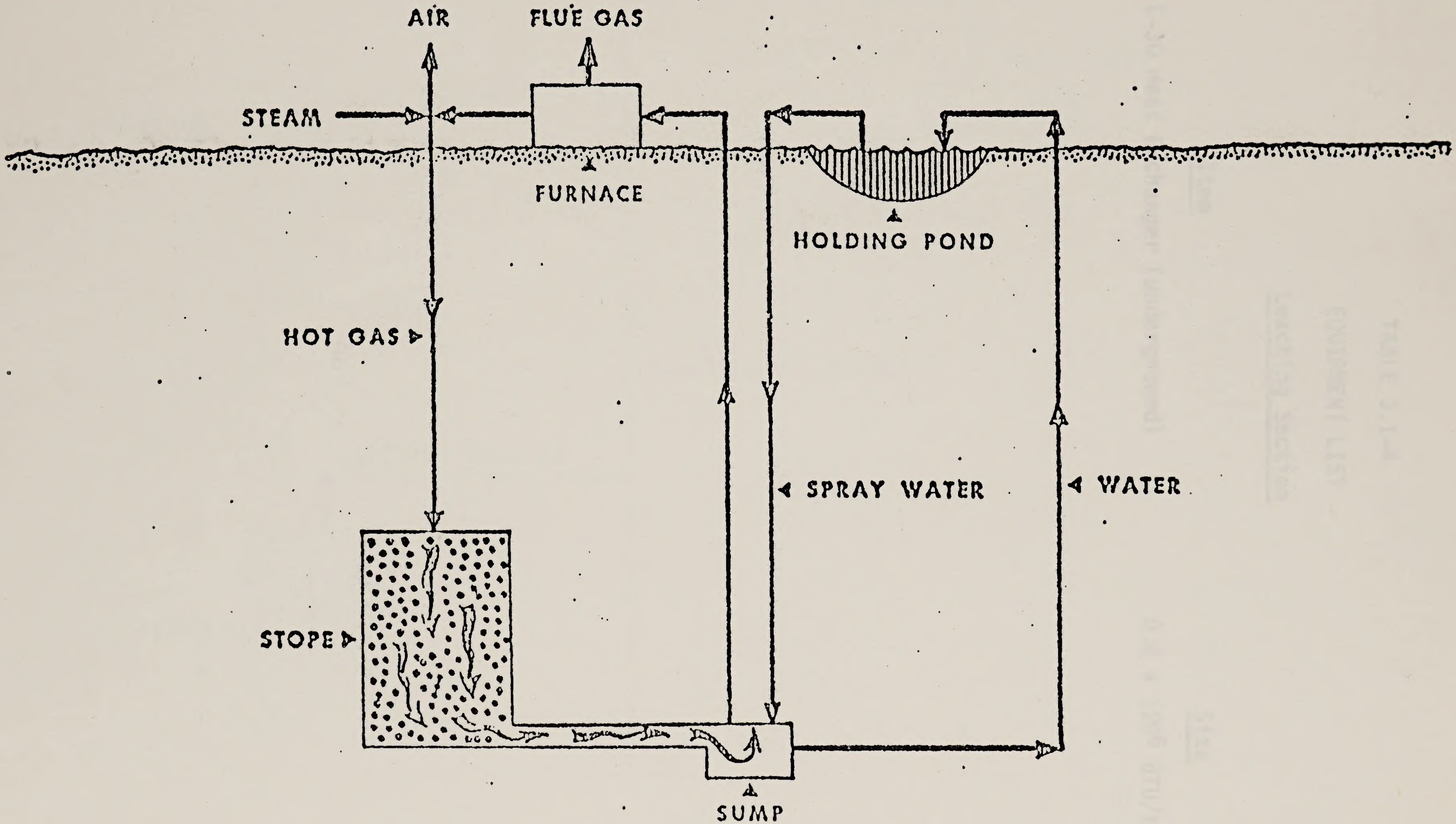
The above-ground piping will be removed from the pipe racks, cut into convenient lengths and prepared for shipment. All valves and control valves will be segregated by size and materials of construction, tagged

TABLE 3.1-3

EQUIPMENT LIST

Pyrolysis and Carbon Recovery Section

Item	Size
V-11 Recycle Gas K.O. Drum	5'6" x 18'
V-13 Product Separator	20,000 Gallons
C-10 Slip Stream Compressor (100 scfm) (Suction +15 psig, Discharge 35 psig)	50 HP
P-10 A,B Product Pump (500 gpm; P 1000) (underground)	500 HP/each
P-11 A,B Product Pump (500 gpm; P 15)	10 HP/each
H-10 Recycle Gas Reheater	35 mm BTU/hr
Y-10 Electrostatic Precipitator (1.1 mm scfh) (Collection area 7000 sq. ft.)	18' x 36' x 20'
E-10 Gas Cooler	0.13 x 10^6 BTU/hr
S-10 Stope (underground)	64' x 40' x 100'
B-10 A,B Recycle Gas Turbo-Blower (0.55 x 10^6 scfh/each) (Suction -4 psig, Discharge 15 psig)	2000 HP/each
V-12 Water Sump (underground)	15' x 15' x 15'
G-70 A,B 440 v. diesel generator	2000 kw
C-70 Air Compressor	600 scfm @ 30 psig
H-70 Steam Generator	1,000 lb/hr @ 30 psig
T-70 A,B Propane Storage	11,000 gal/ea. 9-1/2' x 22'
P-70 A,B Propane Fuel Pump	10 gpm P50
T-71 Diesel Storage	15' x 10'



CARBON RECOVERY AND HEAT RECOVERY SCHEMATIC

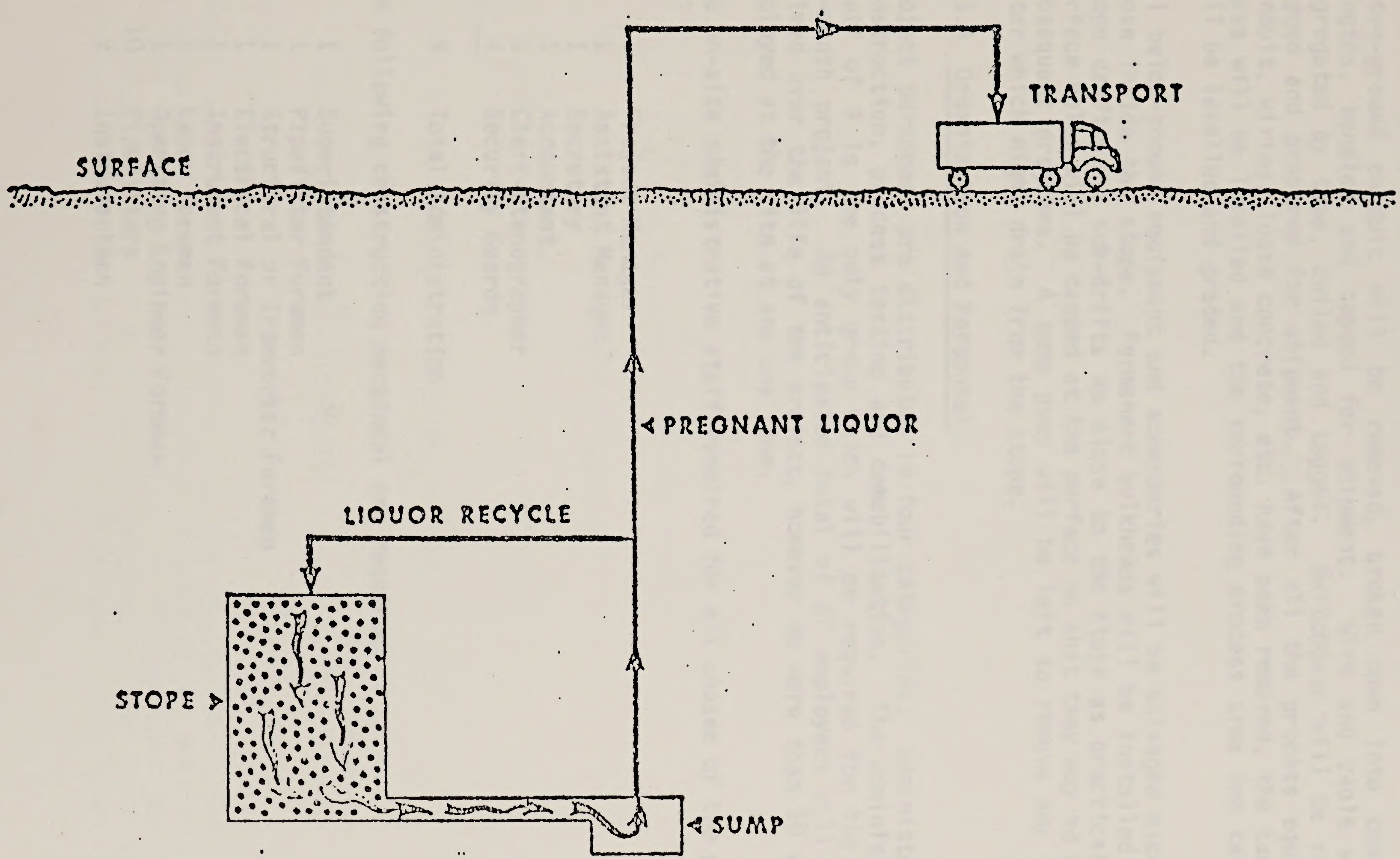
FIGURE 3.1-5

TABLE 3.1-4

EQUIPMENT LIST

Leaching Section

Item	Size
E-30 Heat Exchanger (underground)	0.6×120^6 BTU/hr



LEACHING PROCESS SCHEMATIC

FIGURE 3.1-6

and prepared for shipment. The pipe racks will be dismantled and the structural steel cut to lengths suitable for shipment via truck.

Above-ground conduit will be removed, broken down into convenient lengths, bundled and tagged for shipment. Wire and cable will be segregated by type, coiled and tagged. Switchgear will be removed, tagged and prepared for shipment. After all the process equipment, conduit, wiring, loose concrete, etc. have been removed, the tank farm dikes will be levelled and the surrounding process area and tank farm will be levelled and graded.

All below-ground equipment and accessories will be salvaged except for those inside the stope. Permanent bulkheads will be installed in the stope drifts and sub-drifts as close to the stope as practical. The surface holes will be capped at the surface so that they may be used in subsequent programs. A sump pump will be left to remove any further water which might drain from the stope.

3.3.4 Organization and Personnel

Project personnel are distributed in four categories: administration, construction, process testing and demobilization. The administrative staff of 9 is the only group which will be required for the entire 12-month project. An anticipated total of 87 employees will be involved over the life of the project, however no more than 50 will be employed at the site at any one time.

The on-site administrative staff required for all phases of the program is:

1	Project Manager
1	Assistant Manager
1	Secretary
1	Accountant
1	Clerk-Stenographer
4	Security Guards
9	Total Administration

The following construction personnel are required:

1	Superintendent
1	Pipefitter Foreman
1	Structural or Ironworker Foreman
1	Electrical Foreman
1	Instrument Foreman
1	Labor Foreman
1	Operating Engineer Foreman
10	Pipefitters
2	Instrumentmen

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The on-site administrative staff required for all phases of the program is:

1	Project Manager
1	Assistant Manager
1	Secretary
1	Accountant
1	Clerk-Stenographer
4	Security Guards
9	Total Administration

The following construction personnel are required:

1	Superintendent
1	Pipefitter Foreman
1	Structural or Ironworker Foreman
1	Electrical Foreman
1	Instrument Foreman
1	Labor Foreman
1	Operating Engineer Foreman
10	Pipefitters
2	Instrument men

4	Electricians
2	Operating Engineers
2	Operating Engineers Helpers
10	Laborers
4	Ironworkers
41	Total Construction Personnel

Process testing requires the following personnel:

1	Engineer
4	Unit Foremen
8	Operator Assistants
1	Welder
1	Pipefitter
1	Mechanic
1	Helper
17	Total Operating Personnel

Personnel required for demobilization include:

1	Superintendent
1	Labor Foreman
2	Pipefitters
2	Electricians
10	Laborers
1	Ironworker
2	Welders
1	Equipment Operator
20	Total Demobilization Personnel

3.3.5 Project Economics

Payroll

Payroll costs are expected to be as follows:

Construction phase (6 months)	$ 93,400/month
Testing phase (3 months)	$ 47,544/month
Demobilization phase (3 months)	$ 50,609/month

Project Cost

Project costs have been estimated from the process flow sheets and are presented below. At this early stage of engineering, such an estimate can only be considered to be of an "order of magnitude" nature with an expected accuracy of plus 50% and minus 30%. All costs are 1979 dollars, based on a Marshall & Swift equipment cost index of 620.

Total purchases for equipment and material	$1,836,000
Total amount spent in Rio Blanco County (labor, small subcontracts and some purchases of expendible materials)	315,000
Total value of improvement	
Process equipment, material, and installation labor	$1,402,000
Process utilities	692,000
Electrical distribution and labor	396,000
Subtotal material and labor	$2,490,000
Engineering design, construction overhead and contractor's profit	$ 498,000
Drill, case and insulate 2 holes	1,090,000
Subtotal	$4,078,000
Contingency and allowance for unforeseen items (50%)	$2,039,000
Total	$6,117,000
Salvage value of equipment	$ 551,000

3.4 Project Alternatives

Three alternatives have been examined; the research proposal, no action with the site left as is, and no action but with reclamation of the site.

3.4.1 Proposed Action

The proposed plan would involve utilizing an existing research facility for experimental test work with oil shale, nahcolite and dawsonite. The action proposed would be a 12-month mining research program to determine the potential of mining oil shale deposits at this site and to assess the possible environmental problems associated with these activities.

3.4.2 No Action - USBM Site Preserved

This alternative considers the preservation of the existing USBM site for other research activities. All existing equipment would be left in place and preserved for future operation. Site monitoring for maintenance and security would be carried out by one or two employees on periodic vists to the site.

Deep mining is presently the only method of obtaining bulk samples of nahcolite and dawsonite. At present only the Bureau of Mines has access to bulk samples of these minerals other than at the USBM Tract. Consequently, the surface and underground facilities would be maintained for this type of mining activity.

Research activities related to rock mechanics and mining safety requiring actual or closely simulated mining conditions could be pursued at the existing facilities by another company and/or at a later date.

There are currently no definite plans for other research at the facility.

3.4.3 No Action - USBM Site Reclaimed

Considering the construction activities which have already occurred this alternative may more appropriately be termed the immediate abandonment alternative. Immediate abandonment followed by regrading and reseeding would reduce or eliminate most of the impacts which have previously occurred at the project site. Loss of soils, increased sediment yield and reduced grazing material, however, would remain unchanged. The benefits lost through immediate abandonment include needed environmental and technical research for development of oil shale fuel reserves. A second factor would be the loss of access to bulk samples of dawsonite and nahcolite. No other planned projects in the Piceance Creek Basin will provide access to these minerals and production in any quantity.

A reclamation plan for the facility has been prepared for USBM. It is attached in Appendix A. The plan is designed to return the area to its former use as range land and wildlife habitat. Grading to approximate original contours and revegetation is planned.

3.4.4 Comparison of Alternatives

Implementing either of the No Action plans would mean that research in oil shale recovery using this process would be postponed indefinitely. A valuable resource and a potentially viable recovery procedure may never be utilized.

The No Action - USBM Site Preserved Plan would, at best, delay the research until another plan was approved. The No Action - USBM Site Reclaimed Plan would conclude the entire research facility and a reclamation plan would be implemented to restore the land to its previous state.

The Proposed Action would not only involve oil shale recovery and recovery research but would also include implementation of the reclamation plan upon the dismantling of the research facility.

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SECTION 4.0

AFFECTED ENVIRONMENT

4.1 Ecology

The following section describes the existing ecological conditions in the project area. These include vegetation, wildlife, and aquatic resources, including possible threatened or endangered species and National Natural Landmarks.

National Natural Landmarks are natural areas which are considered of national significance by the Heritage Conservation and Recreation Service (HCRS) of the Department of the Interior under the National Heritage Policy Act. No such sites have been identified in Rio Blanco County as of March 1980 (Natural Landmarks Group, 1980).

4.1.1 Vegetation

The USBM Oil Shale Mining Research Facility is located in the pinyon-juniper ecosystem of the Intermountain Region. There is considerable variation within this broad ecosystem in the western United States; however, the site and its surrounding area encompass only a small portion of the total ecosystem.

There are four major communities in the area of the site, including:

- pinyon-juniper woodland (*Pinus edulis*, *Juniperus osteosperma*);
- chained pinyon-juniper rangeland (plateau shrublands);
- upland sagebrush (*Artemisia tridentata*), and
- bottomland sagebrush (*Artemisia tridentata*).

Other communities present include:

- bunchgrass (*Oryzopsis hymenoides*, *Agropyron spicatum*;
- mixed mountain shrublands (*Quereus gambelii*, *Amelanchier alnifolia*, *Cercocarpus montanus*, *Symphoricarpos oreophilus*;
- greasewood (*Sarcobatus vermiculatus*);
- annual weeds (*Salsola kali*, *Lepidium montanum*, *Bromus tectorum*);
- agricultural meadows (*Phleum pratense*, *Medicago sativa*);
- Great Basin wild rye (*Elymus cinereus*);

- o marshlands (Typha latifolia, Phragmites communis); and
- o riparian (Carex spp.).

The distribution of these types is mapped in Figure 4.1-1. The chained pinyon-juniper rangelands are probably the most extensive community type on the site. The remaining pinyon-juniper woodlands are scattered, but normally occur where chaining was not possible, such as on the sides and bottoms of some smaller draws and on ridgetops bounded by steep slopes.

Upland sagebrush communities occur on ridgetops, sometimes in large clearings in the original woodland. The bottomland sagebrush communities occur on deep alluvial deposits in the gulches, and sometimes extend up the draws in narrow bands to the communities found on the plateaus. The sage found on the deep alluvial deposits grows much larger and is more dense than on the plateaus and ridgetops.

The bunchgrass communities grow on south-facing slopes in the major gulches on colluvium. They also occur on talus slopes between the pinyon-juniper areas and big sagebrush or greasewood communities. Occasionally, bunchgrass communities occur on burned pinyon-juniper areas and on some ridgetops and surrounding slopes.

The mixed mountain shrubland communities occur infrequently on gentle north facing slopes and on relatively dry steep slopes. Occasionally, they are also found on ridgetops and lateral gulches.

Agricultural meadows are only found along the bottomlands of Piceance Creek and are bordered by either marshland communities or riparian communities, or both. Great Basin wild rye communities occur along major stream bottomlands, and only scattered vestiges remain due to the changeover of these areas to agricultural uses.

Appendix A presents the detailed topoedaphic description, structure and composition of the terrestrial plant communities within the USBM Research Facility area.

4.1.2 Wildlife

The major wildlife habitat types, based on vegetation composition, which occur on the USBM tract and the adjacent area are: pinyon-juniper; chained pinyon-juniper; bottomland and upland sagebrush; bunchgrass; mixed mountain shrub; and marshlands, agricultural meadows, and riparian areas in the Piceance Creek floodplain. Wildlife populations within the area are typical of these habitat types. The characteristic plant species found in each of these are discussed in Section 4.1.1 (Vegetation) and Appendix A.

PRELIMINARY VEGETATION MAP
(NO GROUND TRUTH)

FIGURE 4.1-1

Site-specific information presented here is based on a site reconnaissance from June 5 to 8, 1978, discussions with Colorado Division of Wildlife and BLM personnel, the EAR (BLM, 1976) for a previous project at the site and other information, particularly biological studies conducted at Oil Shale Lease Tracts C-a and C-b (Ashland Oil, Inc., 1976; Gulf Oil Corp., 1976).

The most conspicuous and significant wildlife species population known to occur on the USBM site is mule deer (BLM, 1976; Colorado Dept. of Nat. Res. et al., 1977). Historically, the Piceance Creek Basin supported the largest migrating herd of mule deer in the Americas (Getman, 1980). During the early 1960's an estimated 70 to 80 thousand deer wintered in the basin. Currently, 20 thousand deer utilize the basin. Herd size is predicted to reach 40 thousand if BLM goals can be realized (Getman, 1980). The region around the USBM tract is an important winter range for mule deer and the USBM tract itself is within a winter concentration area considered to be important deer habitat. The approximate boundaries of this winter range and the concentration areas are shown in Appendix A, Figure 1.

The USBM tract is located within the winter range of mountain lions (Appendix A, Figure 2). However, areas of concentration do not occur near the project site (Colorado Dept. of Nat. Res. et. al, 1977) and the site is not considered to be a significant or critical habitat area for this species.

The USBM tract is not within the summer or winter range of elk and is outside the area generally used by black bear. An occasional individual of these species might be found on the tract, but their utilization of the project site is not expected to be significant (Colorado Division of Wildlife, 1975; Colorado Dept. of Nat. Res. et al., 1977).

The most significant predatory mammals expected to be found on the USBM tract include coyote and bobcat. Weasels, striped skunk, gray fox and raccoon are also expected to occur in low numbers.

A variety of small mammal species are expected to utilize the USBM tract. The primary species, based on data from studies conducted at Oil Shale Lease Tracts C-a and C-b in similar habitat types, are the deer mouse and the least chipmunk.

Sage grouse occur throughout much of the Piceance Creek basin area. The portion of their range in which the USBM tract is located contains a moderate density of individuals relative to the other populations of Rio Blanco County and is not considered critical or unusually important habitat (Colorado Division of Wildlife, 1975; Getman, 1980). No winter concentration areas or strutting grounds are known within approximately six miles of the site (Appendix A, Figure 3).

Site-specific information presented here is based on a site reconnaissance from June 6 to 8, 1979, discussions with Colorado Division of Wildlife and BLM personnel, the EAR (BLM, 1975) for a previous project at the site and other information, particularly biological studies conducted at Oil Shale Lease Tracts C-a and C-b (Ashland Oil, Inc., 1976; Gulf Oil Corp., 1976).

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Both ducks and shorebirds occur throughout the Piceance Creek river bottom. A nesting area and concentration area of ducks occurs adjacent to the USBM tract (about one mile from the area of surface activity) and nesting and feeding areas of shorebirds occur in this vicinity as well. The approximate locations of these areas are shown in Appendix A, Figure 4.

The major raptor species occurring in the region of the USBM tract are the golden eagle and red-tailed hawk. The distribution of nests for these species indicates that the USBM tract is very likely utilized for foraging but is not an important nesting area (Colorado Dept. of Nat. Res. et al., 1977; Craig, pers. comm., 1977; Elderkin pers. comm., 1980). In addition, great horned owls are fairly common in the area and several Cooper's hawks have recently been sighted in the area (Craig, pers. comm., 1977). The USBM tract would be utilized by these species.

Bird species present on the USBM tract are expected to be comparable to those found in similar habitat types throughout the area. The most common resident species in the pinyon-juniper and sage areas would include common flicker, horned lark, scrub and pinyon jays, raven, black-billed magpie, mountain chickadee and plain titmouse. Typical summer residents expected in these habitats are house wren, American robin, mountain bluebird, blue-gray gnatcatcher, black-throated gray warbler, green-tailed towhee, and chipping and Brewer's sparrows. In addition, bald eagle, dark-eyed junco, northern shrike and Townsend's solitaire are expected during winter.

In the Piceance Creek river bottom, mallard, teal and redhead ducks, marsh hawk, killdeer, mourning dove, Say's phoebe, barn and cliff swallows, western meadowlark, and red-winged and Brewer's blackbirds are expected at some time during the year.

A variety of important species including antelope, white-tailed prairie dog, band-tailed pigeon, blue grouse, and other game birds do not occur within the vicinity of the USBM tract (Colorado Dept. of Nat. Res. et al., 1977; Colorado Division of Wildlife, 1975).

The abundance and diversity of reptiles and amphibians in the project site and adjacent area is expected to be low due to the cold winter, limited permanent water and rainfall.

Three species listed as endangered by the U.S. Department of Interior occur or have been observed in the region in which the project is located. Peregrine falcons have been observed in the vicinity of Oil Shale Lease Tract C-a during 1974-75 and suitable habitat for nesting and/or roosting occurs about twenty miles southeast of the project area (Colorado Dept. of Nat. Res. et al., 1977; Gulf Oil Corp., 1976). Bald eagle are present in the Piceance Creek area during winter months. Sightings were reported during the winter of 1974-75 on or near both

Tracts C-a and C-b, which are about ten miles west and ten miles southeast of the project site, respectively. An overwintering concentration area is located along much of the White River about 12 miles north of the project site (Colorado Dept. of Nat. Res. et. al., 1977). A single, immature whooping crane was observed in the project site region during its migration through the area (Craig, pers. comm., 1977). The regular occurrence of this species in the area is unknown and its utilization of the area is considered unlikely.

Nesting individuals of greater sandhill cranes are considered endangered by the State of Colorado. Individuals have been observed in the vicinity of the project area, however, no evidence of nesting was found during nesting surveys (Gulf Oil Corp., 1976). The sightings are considered to be of individuals which occasionally stop in the vicinity of the USBM Tract during migration and do not represent a breeding population (Getman, pers. comm., 1980).

No species of federal or state threatened or endangered status are known to regularly occur on, or significantly utilize, the project site (BLM, 1976; Colorado Dept. of Nat. Res. et al., 1977; Getman, 1980; Elderkin, 1980).

4.1.3 Aquatic Biology

The information presented in this section was summarized from the Detailed Development Plan (Vol. 2) for Federal Prototype Oil Shale Lease Tract C-b, prepared by Ashland Oil Corporation and others (1976).

Piceance Creek is characterized by a meandering stream channel with fluctuating flows, high levels of dissolved solids, high turbidity and infrequent pool and shelter areas for fish. These factors make the creek suitable for highly adaptable non-game fish but generally unsuitable for large game fish populations.

Predominant fish species in the vicinity of the confluence of Horse Draw and Piceance Creek are the mountain sucker (Catostomus platyrhynchus), speckled dace (Rhinichthys osculus) and flannelmouth sucker (Catostomus latipinnis). These species generally increase in an upstream direction. Piceance Creek, from its confluence with Horse Draw to its headwaters, supports few, if any, fish (BLM, 1976).

Piceance Creek is thought to be the only locality in Colorado known for mountain sucker where it appears to be well established and thriving (Ashland Oil, 1976). Mountain sucker range in abundance from 32+7 to 68+38 fish per 100-meter stretch of the creek depending on sample station location (Ashland Oil, 1976). Information, if any, on speckled dace, flannelmouth sucker and other relevant species populations is not available at this time.

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Piceance Creek is thought to be the only locality in Colorado known for mountain sucker where it appears to be well established and thriving (Ashland Oil, 1976). Mountain sucker range in abundance from 3387 to 5638 fish per 100 meter length of the creek depending on sample station location (Ashland Oil, 1976). Information, if any, on speckled dace, flannelmouth sucker and other relevant species populations is not available at this time.

The White River, north of the USBM tract, supports small populations of non-game fish including minnows, flannelmouth sucker, mottled sculpin and speckled dace (BLM, 1976). White fish, a game fish species, is found at the confluence of Piceance Creek and the White River, but their population is thought to be low (BLM, 1976). Ryan Pond, located outside the USBM tract, supports a small population of small mouth bass (BLM, 1976).

Within Piceance Creek, benthic Arthropod orders, utilized as fish food, include Diptera, Plecoptera, Trichoptera, Coleoptera and Ephemeroptera; the greatest abundance occurs in summer and fall. Areas of mud and clay substrate, downstream of Tract C-b oil shale tract, provide poor habitat for benthic fauna.

Algae are the only significant periphyton and its productivity is very low on Piceance Creek in the vicinity of the USBM tract.

The most commonly encountered form of Lentic community in the Piceance Creek is watercress (Nasturtium rorippa aquaticum). Snow runoffs in the spring swell the creek, increasing its silt load. Growth of plants and algae tend to be retarded by the resultant cold water temperatures and high turbidity during the spring season. However, by late summer plants recover and growth is luxuriant due to cleaner water and higher temperatures.

Squawfish, a federally endangered species of fish, have been found in the White River near the confluence of Piceance Creek and the White River about 15 miles downstream from the project area (Getman, 1980).

4.2 Air Resources

4.2.1 Regional Climatology

Colorado exhibits two distinct climatic regions. The eastern half of the state is high plains, consisting of flat, even terrain which slopes gently to the east. The high plains are described in climatic terms as "continental" because they are well removed from most direct influences of oceans or large bodies of water. The high plains are generally dry, receiving only 30 to 36 cm (12 to 14 in.) of precipitation each year. This moisture is usually in the form of locally heavy thunderstorms during the summer and heavy snows during the winter when moisture laden systems flow from the midwest and Gulf states.

The western half of Colorado exhibits a much greater variability in climate due to the extreme variations in elevation and to local topographic features. Normal precipitation in the area ranges from 18 cm (7 in.) to greater than 64 cm (25 in.) annually. Much of the annual precipitation in western Colorado occurs during the winter months when storm systems from the Pacific Northwest bring moisture and cold temperatures to the mountains. Moisture is removed as the

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Within Piceance Creek, benthic invertebrate genera, utilized as fish food, include Diptera, Plecoptera, Trichoptera, Coleoptera and Ephemeroptera; the greatest abundance occurs in summer and fall. Areas of mud and clay substrate, characteristic of tract C-a and White Creek, provide poor habitat for benthic fauna.

Algae are the only significant periphyton and its productivity is very low on Piceance Creek in the vicinity of the USGS tract.

The most commonly encountered type of aquatic community in the Piceance Creek is watercress (Nasturtium officinale) communities. Snow runoffs in the spring swell the creek, increasing the silt load. Growth of plants and algae tend to be retarded by the resultant cold water temperatures and high turbidity during the spring season. However, by late summer plants recover and growth is luxuriant due to clearer water and higher temperatures.

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systems pass over the higher elevations. Some locally heavy thunderstorms occur in the summer, resulting in occasional flash flooding.

4.2.2 Local Climatology

Sixty-five weather reporting stations are located in the Colorado River Drainage basin of western Colorado (Figure 4.2-1). Grand Junction is the only station in the area which has Local Climatological Data (LCD) provided by the National Climatic Center. The LCD for Grand Junction are more detailed than data reported by other stations in the area and represent a data base of greater than 86 years. The Grand Junction data are not necessarily representative of the USBM Oil Shale Mining Research Facility and are used only when they reasonably reflect the conditions at the USBM tract.

The topographic position of the USBM site, within a mountain valley (Horse Draw), is partially responsible for a climate of few storms and abundant sunshine. The USBM tract is surrounded by high mountains and, as a result, many low pressure storm centers are deflected around the area. High pressure systems move in from the west coast and often persist for several days. These conditions result in clear skies with abundant sunshine and low precipitation. The great number of clear sky days promotes rapid heating of the land during the day and also rapid cooling at night resulting in warm days and cool nights during the summer. The additional radiative cooling when a snow cover exists produces greater diurnal temperature changes in the winter.

Elevation and local terrain greatly affect the climate experienced at any particular site in the area. Table 4.2-1 illustrates some of the climatic conditions around the USBM tract. Although the data are arranged according to elevation, it is shown that the normal temperatures, growing days, and precipitation do not necessarily coincide with this scheme. The differences are largely due to whether a station is located in a valley or on a plateau.

4.2.3 Local Meteorology

Synoptic-scale weather patterns determine the general weather in the area, but topography plays the largest role in site specific weather. Sites located in mountain valleys, as is the USBM tract, are subject to small scale circulations or wind patterns induced by the valleys themselves. Two of these wind patterns that occur in the USBM tract are called mountain-valley winds and upslope-downslope winds. Depending on the orientation of the valley axis to the upper level winds, these two wind patterns may enhance or oppose the general prevailing wind.

Mountain winds usually occur when the lower level plains are warmer than the mountains. The warm, lighter air in the plains rises and

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FIGURE 4.2-1
WEATHER REPORTING STATIONS IN THE COLORADO RIVER
DRAINAGE BASIN OF WESTERN COLORADO

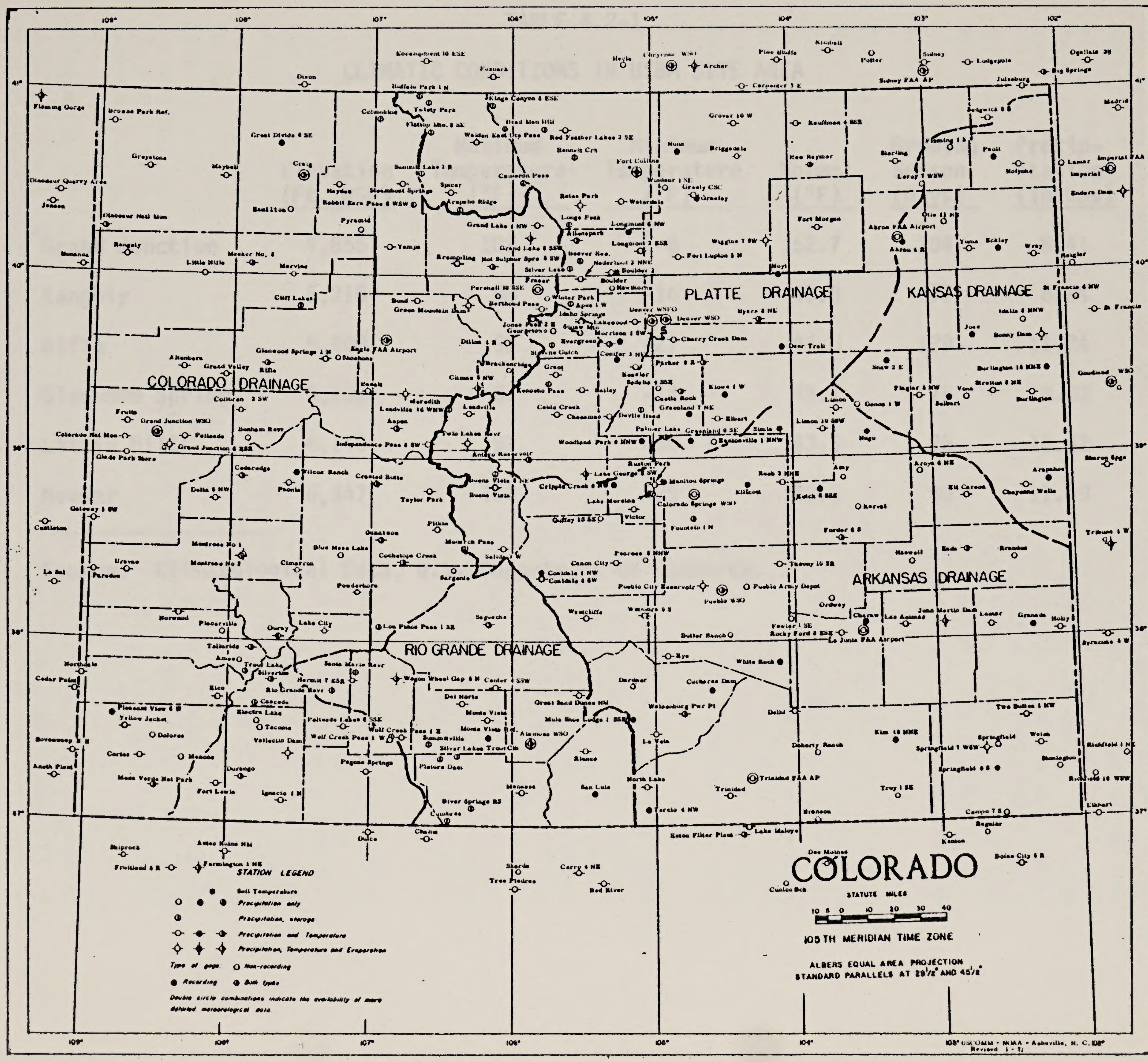


TABLE 4.2-1

CLIMATIC CONDITIONS IN USBM SITE AREA

	Elevation (Ft. MSL)	Maximum Temperature (°F)	Minimum Temperature (°F)	Normal (°F)	Growing Season (Days)	Precipitation (inches)
Grand Junction	4,855	102	-8	52.7	204	8.41
Rangely	5,216	98	-16	43.8	77	8.24
Rifle	5,400	92	-27	47.8	129	11.24
Glenwood Springs	5,823	97	-14	48.1	75	18.03
Little Hills	6,140	92	-30	43.5	25	10.62
Meeker	6,347	108	-25	42.6	60	11.09

Source: Climatological Data, U.S. Department of Commerce.

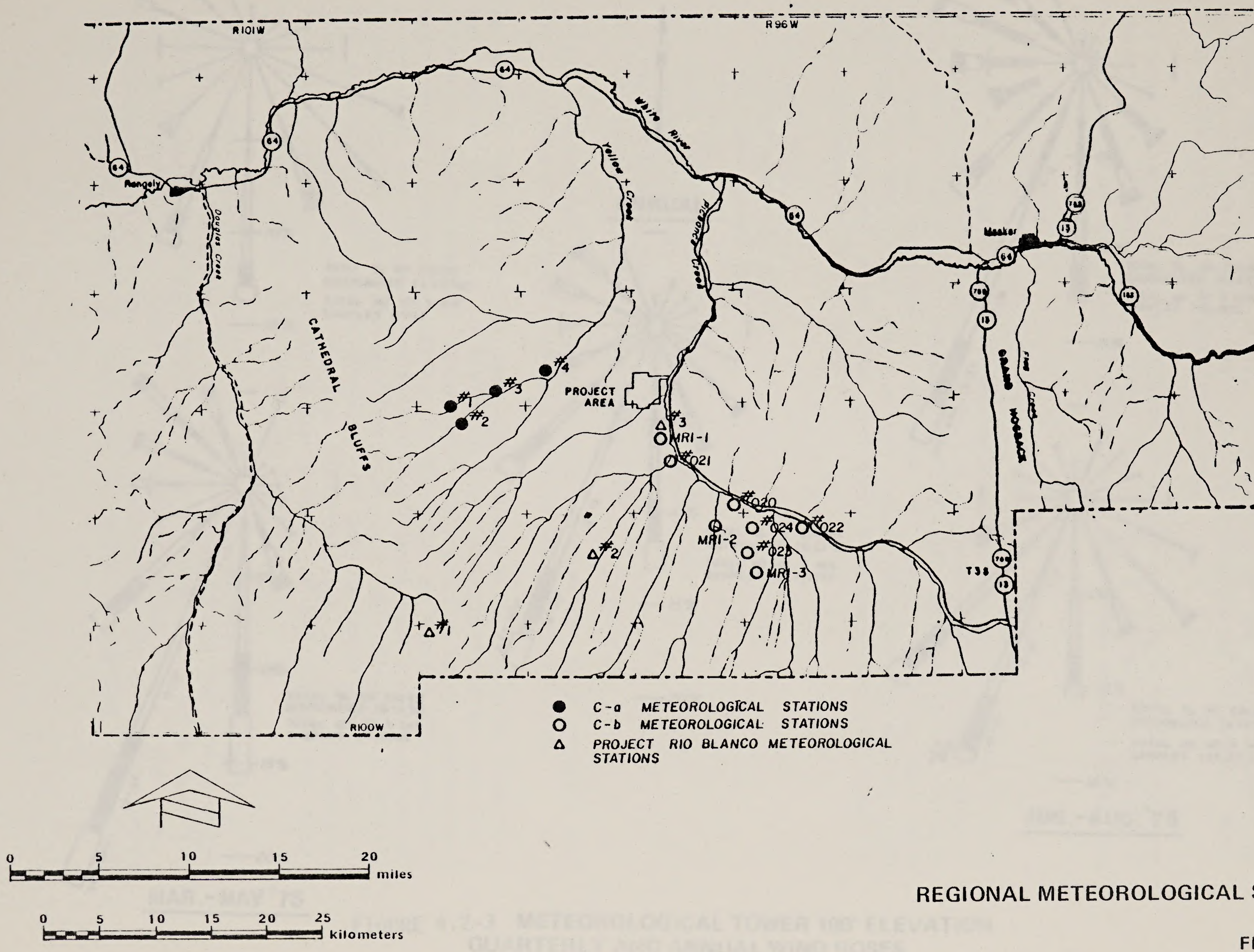
is replaced by the cooler mountain air which flows down the valleys. These winds frequently occur in the late afternoon and at night when the mountains have cooled more rapidly than the warmer plains. The reverse of mountain winds are called valley winds. These winds are again caused by the different heating rates of the mountains and lower plains. Valley winds are normally experienced during the late morning and afternoon. In this case the mountains have warmed faster than the plains because the rising sun irradiates the mountains at a more nearly perpendicular angle. The resulting flow of air to the mountains is constrained by the valleys and hence, the valley winds. Cloud cover and synoptic systems may modify, delay, or eliminate the mountain and valley winds in some cases.

The second type of local terrain-induced flow is the upslope and down-slope winds. These winds are also produced by differences in heating rates, but on a much smaller scale than mountain-valley winds. Upslope winds are caused when valley walls are heated more quickly than the valley floor. The warmer air near the valley walls rises and creates the upslope winds. During the late afternoon and evening cooler air from the higher elevations drains into the mountain valleys and creates the downslope winds.

Site-specific meteorological information does not exist at the USBM tract at this time; however, much information has been, and is being, collected at sites throughout the Piceance Creek Basin (Figure 4.2-2). Many of these sites are located in valleys draining into Piceance Creek. The data from these sites indicate that the mountain-valley and upslope-downslope winds are the major factors determining circulations in the valleys. Data have also been taken on the ridges and plateaus above the valleys and indicate that the major influence on wind speed and direction at those sites is the upper level winds in the atmosphere.

Grand Junction 700 millibar wind data at approximately 10,000 feet are believed to represent closely the 700 millibar winds over the Piceance Creek Basin. Four year averages of 700 millibar winds for the months of June, August, October, December, February and April are presented in Appendix B. The data show that the direction is from the west to southwest. These winds, when exhibited near the surface, turn to the left and blow from a more southerly direction due to frictional effects with the surface. Wind data taken at the Federal Oil Shale Lease Tract C-b site 023 show that the greatest frequency of wind, 31 m (100 ft) from the surface on top of a plateau, is from the south southwest (Figure 4.2-3).

Meteorological data were obtained for the U.S. Atomic Energy Commission's Project Rio Blanco (1971) in a mountain valley, approximately 16 km (10 miles) south of the USBM tract. The RB-2 site was in a valley oriented in a direction similar to the USBM tract valley. In Appendix B, the direction and frequency in which the wind blows are shown by



REGIONAL METEOROLOGICAL STATIONS

FIGURE 4.2-2

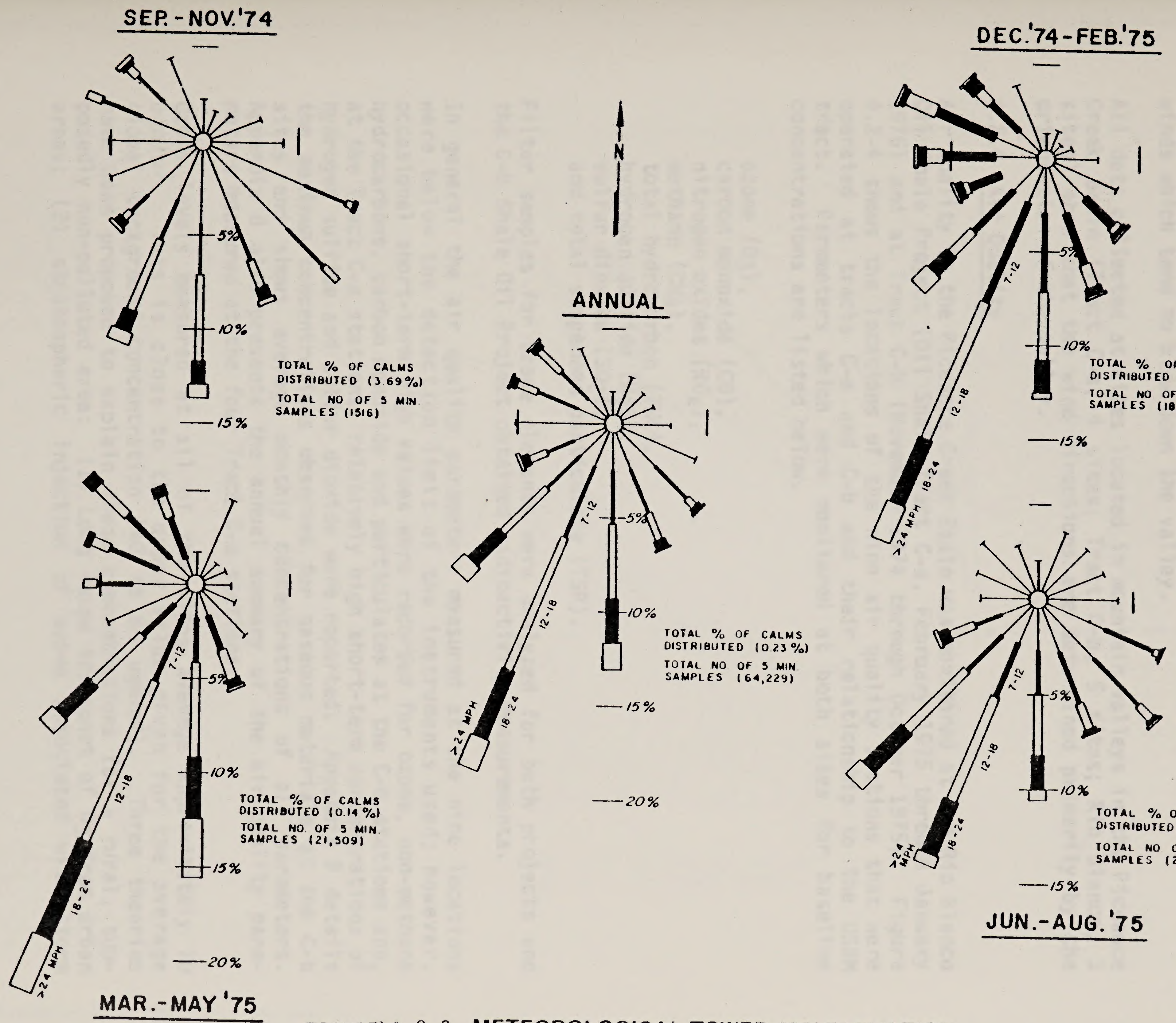


FIGURE 4.2-3 METEOROLOGICAL TOWER 100' ELEVATION QUARTERLY AND ANNUAL WIND ROSES

wind roses. The data have been divided into eight 3-hour time blocks to show the diurnal variations. Mountain-valley and upslope-downslope contributions are noted as well as the influence of the upper level winds which tend to blow down the valley.

All data collected at sites located in mountain valleys in the Piceance Creek Basin (Tract C-a, 4 sites; Tract C-b, 5 sites; Rio Blanco, 3 sites) show that the wind directions are determined primarily by the orientation of the valley.

4.2.4 Air Quality

Air quality in the Piceance Creek Basin was monitored at the Rio Blanco Oil Shale Project (Oil Shale Tract C-a, February 1975 through January 1976) and at Tract C-b (November 1974 through October 1975). Figure 4.2-4 shows the locations of the nine air quality stations that were operated at tracts C-a and C-b and their relationship to the USBM tract. Parameters which were monitored at both sites for baseline concentrations are listed below.

ozone (O_3),
carbon monoxide (CO),
nitrogen oxides (NO_x),
methane (CH_4),
total hydrocarbon (THC),
hydrogen sulfide (H_2S),
sulfur dioxide (SO_2),
and total suspended particulate (TSP).

Filter samples for trace elements were analyzed for both projects and the C-b Shale Oil Project obtained radioactivity measurements.

In general the air quality parameters measured at the nine locations were below the detection limit of the instruments used; however, occasional short-term high values were recorded for ozone, non-methane hydrocarbons, carbon monoxide and particulates at the C-b stations and, at the Tract C-a stations, relatively high short-term concentrations of hydrogen sulfide and sulfur dioxide were reported. Appendix B details the maximum concentrations observed for gaseous materials at the C-b sites and shows average monthly concentrations of all parameters. Appendix B also presents the annual summary of the air quality parameters measured at the four Tract C-a stations.

Ozone levels measured at all of the sites average approximately 70 ugm/m^3. This is close to the upper value given for the average global background concentration (40 to 80 ugm/m^3). Three theories have been proposed to explain these concentrations for a rural, supposedly non-polluted area: (1) Long range transport of O_3 from urban areas; (2) stratospheric injection of ozone associated with storm

wind roses. The data have been divided into eight 3-hour time blocks to show the diurnal variations. Mountain-valley and upslope-downslope contributions are noted as well as the influence of the upper level winds which tend to blow down the valley.

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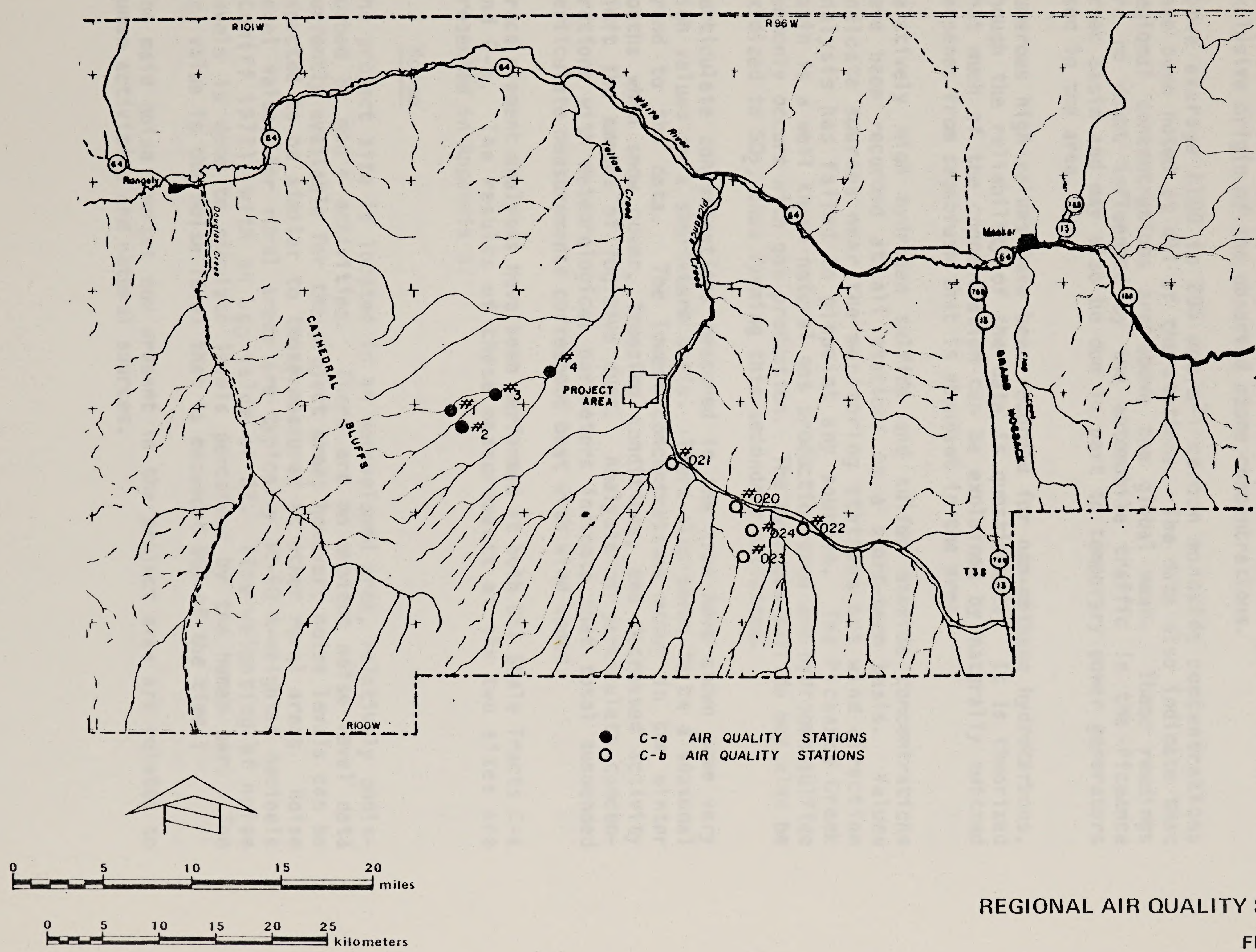
total hydrocarbon (THC),
hydrogen sulfide (H_2S),
sulfur dioxide (SO_2),
and total suspended particulates (TSP).

Filter samples for trace elements were analyzed for both projects and the C-b Shale Oil Project obtained radioactivity measurements.

In general the air quality parameters measured at the nine locations were below the detection limit of the instruments used; however, occasional short-term high values were recorded for ozone, non-methane hydrocarbons, carbon monoxide and particulates at the C-b stations and, at the Tract C-a stations, relatively high short-term concentrations of hydrogen sulfide and sulfur dioxide were reported. Appendix D details the maximum concentrations observed for gaseous materials at the C-b sites and shows average monthly concentrations of all parameters. Appendix D also presents the annual summary of the air quality parameters measured at the four Tract C-a stations.

Ozone levels measured at all of the sites average approximately 70 ugm/m³. This is close to the upper value given for the average global background concentration (40 to 80 ugm/m³). Three theories have been proposed to explain these concentrations for a rural, supposedly non-polluted area: (1) long range transport of O_3 from urban areas; (2) stratospheric injection of ozone associated with storm



REGIONAL AIR QUALITY STATIONS

FIGURE 4.2-4

fronts; and (3) photochemical reactions with naturally occurring hydrocarbons. None of the above explanations has been shown to be the exclusive origin of the observed ozone concentrations.

Above average (100 to 200 ugm/m^3) carbon monoxide concentrations have been noted at all of the stations. The data also indicate that regional concentrations are above the global mean. These readings are no doubt influenced by the automobile traffic in the Piceance Creek Basin and may also be due in part to temporary power generators used in the area.

Numerous high values have been recorded for non-methane hydrocarbons, though the reliability of the data is questionable. It is theorized that much of the concentration can be explained by naturally emitted terpenes from sagebrush that is abundant in the area.

Relatively high hydrogen sulfide and sulfur dioxide concentrations have been recorded at all stations on a short-term basis. Values indicate sources near the monitoring stations but wind direction analysis has failed to pinpoint any sources. The Piceance Creek Basin is a well known natural gas production area and hydrogen sulfide commonly occurs with gas production. The hydrogen sulfide may also be oxidized to SO_2, thus forming this secondary pollutant.

Particulate concentrations measured in the area have shown some very high values on a short-term basis. There also seems to be a seasonal trend to the data. The lowest concentrations occur in the winter months when snow cover, freezing conditions, and decreased activity limit the amount of fugitive dust. Analysis of particulate concentrations with meteorological parameters indicate that total suspended particulate measurements correspond best with wind speed.

Trace element analyses have been performed at both Oil Shale Tracts C-a and C-b. The results of these measurements at the two sites are presented in Appendix B.

4.3 Noise

The project site is located in an undeveloped area, relatively undisturbed by man's activities. There are no ambient noise level data currently available for the project area; however, noise levels can be expected to be similar to those measured at other rural areas. Noise level values for rural areas are typically 30-50 A-weighted decibels (Cuniff 1977), with an L_{50} value of 37. (The weighting of noise levels is done to simulate levels perceived by the human ear. The L_{50} value is the noise level that is exceeded 50% of the time.)

The main noise sources now present in the project area are related to human activities and natural sources.

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Relatively high hydrogen sulfide and sulfur dioxide concentrations have been recorded at all stations on a short-term basis. Values indicate sources near the monitoring stations but wind direction analysis has failed to pinpoint any sources. The Piceance Creek Basin is a well known natural gas production area and hydrogen sulfide commonly occurs with gas production. The hydrogen sulfide may then be oxidized to SO_2, thus forming this secondary pollutant.

Particulate concentrations measured in the area have shown some very high values on a short-term basis. There also seems to be a seasonal trend to the data. The lowest concentrations occur in the winter months when snow cover, freezing conditions, and decreased activity limit the amount of fugitive dust. Analysis of particulate concentrations with meteorological parameters indicates that total suspended particulate measurements correspond best with wind speed.

Trace element analyses have been performed at both Oil Shale Tracts C-a and C-b. The results of these measurements at the two sites are presented in Appendix E.

4.3 Noise

The project site is located in an undeveloped area, relatively undisturbed by man's activities. There are no ambient noise level data currently available for the project area; however, noise levels can be expected to be similar to those measured at other rural areas. Noise level values for rural areas are typically 30-50 A-weighted decibels (Cuniff 1977), with an L_{50} value of 37. (The weighting of noise levels is done to simulate levels perceived by the human ear. The L_{50} value is the noise level that is exceeded 50% of the time.)

The main noise sources now present in the project area are related to human activities and natural sources.

4.4 Geology and Soils

4.4.1 Regional and Project Area Physiography

The USBM Oil Shale Mining Research Facility is located near the center of the Piceance Creek Basin, a 4144 square kilometer (1600 mi^2) elevated structural basin. The basin is situated in the northeast portion of the Colorado Plateau. Within the basin lies a dissected plateau with relief diminishing from south to north. Elevations therefore exhibit the greatest variation in the southern portion of the basin, from 1524 m (5000 ft) in the extreme south to more than 2743 m (9000 ft) in the Roan Cliffs.

The topography of the USBM tract is moderately dissected with slope angles which range from 0-45°. In the valleys of Horse Draw, Ryan Gulch, and Piceance Creek, the surface is flat to gently sloping (0-2°). The top of the dissected plateau above these valleys is rolling, with slope angles averaging about 4°. The plateau has been dissected by ephemeral washes forming moderately to steeply sloping hillsides. The average slope of the hillsides ranges from about 8° south of Horse Draw to about 20° north of Horse Draw and Ryan Gulch. North of the research facilities site, immediately north of Horse Draw, slope angles are about 45°, the steepest in the USBM tract.

The USBM tract has a drainage pattern which ranges from trellis to parallel, reflecting adjustment of stream and wash valleys to bedrock jointing.

Total relief within the USBM tract is more than 201.5 m (650 ft); elevations range from 1844.5 m (6050 ft) along Piceance Creek to 2047 m (6717 ft) above sea level at the northwest corner of Section 30.

4.4.2 Stratigraphy

The USBM tract is underlain by formations ranging in age from Pre-Cambrian to Recent. Table 4.4-1 shows a stratigraphic section of late Cretaceous to Recent sedimentary strata which are exposed at the surface in the Piceance basin. Since only the Green River formation, Uinta formation and Quaternary deposits will be affected by proposed MMC research development activities, discussion of the Wasatch and older units will be excluded from this text.

The Green River formation overlies the older Wasatch formation and is of middle Eocene age. The sediments comprising the formation are fluvial and lacustrine in origin. In the project area the formation is comprised of the Douglas Creek, Garden Gulch, and Parachute Creek members. The Parachute Creek member contains kerogen-rich marlstone and deposits of dawsonite and nahcolite. Underground research activities will be conducted within the Parachute Creek member.

TABLE 4.4-1

STRATIGRAPHIC SECTION OF
PICEANCE CREEK BASIN

GEOLOGIC AGE: ERA	PERIOD	EPOCH	GEOLOGIC UNIT	TOPOGRAPHIC EXPRESSION	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	THICKNESS (FEET)
Cenozoic	Quaternary	Recent and Pleistocene	Alluvium	Stream valleys	Unconsolidated gravel, sand, and clay.	Fluviatile	0-200
Cenozoic	Tertiary	Pliocene	Basalt flow	Summit of Mount Callahan	Labradorite with a high percentage of mafic minerals.	Volcanic	Small
Cenozoic	Tertiary	Eocene	Uinta Formation	Buff to brown rounded receding caps on the plateau rim and rough hilly topography in the central part of the Basin	Fine to medium-grained, lenticular, massive, brown sandstone, white to grey lenticular siltstone, white to grey marlstone, generally barren of kerogen and shale.	Fluviatile-Lacustrine	0-1,250
Cenozoic	Tertiary	Eocene	Green River Formation: Parachute Creek Member	Whitish cliffs	White to grey varved dolomitic marlstone with alternating dark kerogen-rich and light barren zones, and sodium minerals, principally nahcolite dawsonite, and halite.	Lacustrine	500-1,230
Cenozoic	Tertiary	Eocene	Green River Formation: Anvil Points Member (lateral equivalent to Douglas Creek, Garden Gulch, and lower Parachute Creek Members in the eastern part of the Basin)	Benches and cliffs	Grey shale, interbedded gray shale and brown and gray sandstone, massive brown and gray sandstone, light brown marlstone, generally barren of kerogen. Minor amounts of siltstone and algal and oolitic limestone.	Lacustrine (near-shore facies)	0-1,870
Cenozoic	Tertiary	Eocene	Green River Formation: Garden Gulch Member	Gray steep slopes	Dark, finely laminated, papery to flaky shale and dolomitic marlstone, generally barren of kerogen. Locally thin beds of sandstone, breccia, and algal, oolitic, and ostracodal limestone.	Lacustrine	0-900
Cenozoic	Tertiary	Eocene	Green River Formation: Douglas Creek Member	Benches	Brown to buff cross-bedded and ripple-marked sandstone, algal and ostracodal limestone, and oolitic sandstone and limestone with minor gray shale.	Lacustrine	0-800
Cenozoic	Tertiary	Eocene	Wasatch Formation	Lowlands	Buff lenticular sandstone and irregularly-bedded brightly-colored shale with minor amounts of limestone, conglomerate, coal, and black carbonaceous shale.	Fluviatile	300-5,500
Cenozoic	Tertiary	Paleocene	Unnamed unit	Ledges	Brown sandstone, dark-colored shale, and a few thin coal beds.	Continental with scattered short-lived swamps	500
Cenozoic	Tertiary	Paleocene	Ohio Creek conglomerate		Black and red chert and quartzite pebbles in a white sandstone matrix.	Continental	20
Mesozoic	Cretaceous	Late Cretaceous	Mesaverde Group	Prominent cliffs, benches, or ridges	Tan to brown fine to coarse-grained sandstone interbedded with shale and several coal beds.	Fresh water, brackish and marine at or near ancient strand lines	5,600

SOURCE: Golder Associates, 1977a, Table 3-1.

Because of its high content of kerogen-rich marlstone (oil shale), the Parachute Creek member of the Green River formation is of significant economic importance. The member consists of three zones, which are from oldest to youngest, the high resistivity (saline) zone, the low resistivity zone (lower aquifer or leached zone), and the Mahogany zone. A cross section which illustrates the three zones of the Parachute Creek member in the vicinity of the USBM tract is shown in Figure 4.4-1. The low resistivity zone of the Parachute Creek Member contains laterally extensive strata of white to gray, varved dolomitic marlstone with alternating, dark, kerogen-rich and light barren zones. The high resistivity zone contains concentrations of sodium minerals, principally nahcolite, dawsonite, and halite interbedded with oil shale. The Mahogany is the richest oil shale zone within the member. The Parachute Creek member is about 457 m (1500 ft) thick beneath the USBM site.

The Uinta formation overlies the Green River formation and crops out within the USBM tract as shown by Figure 4.4-2. Within the USBM tract its thickness ranges from about 183 m (600 ft) in the Piceance Creek Valley to about 427 m (1400 ft) at the northwest corner of the study area. The formation is late Eocene in age and was deposited in an initially lacustrine and pluvial environment which became progressively more fluvial with time. The sediments comprising the formation consist of fine- to medium-grained, lenticular, massive brown sandstone, white to gray lenticular siltstone, and white to gray marlstone. The sandstone becomes increasingly more prominent toward the top of the formation. Kerogen-containing marlstone beds are present near the base. This rock weathers to buff and light brown.

Quaternary deposits shown on Figure 4.4-2 include alluvium in the valleys of Piceance Creek, Ryan Gulch, and Horse Draw, and colluvium which is concentrated at the base of steep hillsides in the project area. Nearly all of this material in the project area has been deposited in the Holocene Epoch.

Alluvium consists of stream-deposited, unconsolidated gravel and sand derived from the Uinta formation. The sand and gravel contain stringers of clay near mouths of small tributaries to major streams. The alluvium has a maximum thickness of about 30 m (100 ft) in the Piceance Creek valley portion of the USBM Tract, about 21 m (70 ft) in Ryan Gulch and probably less than 21 m (70 ft) in Horse Draw (Coffin et al., 1971).

Colluvium consists of unconsolidated, heterogenous masses of soil material and rock fragments.

4.4.3 Structural Geology of the Region and Project Area

The Piceance Creek Basin is a northwest-trending structural downwarp which is asymmetric, with gently dipping limbs on the south and west

Because of its high content of kerogen-rich marlstone (oil shale), the Parachute Creek member of the Green River formation is of significant economic importance. The member consists of three zones, which are from oldest to youngest, the high resistivity (saline) zone, the low resistivity zone (lower aquifer or leached zone), and the Mahogany zone. A cross section which illustrates the three zones of the Parachute Creek member in the vicinity of the USBM tract is shown in Figure 4.4-1. The low resistivity zone of the Parachute Creek Member contains laterally extensive strata of white to gray, varved dolomitic marlstone with alternating, dark, kerogen-rich and light barren zones. The high resistivity zone contains concentrations of sodium minerals, principally nahcolite, dawsonite, and halite interbedded with oil shale. The Mahogany is the richest oil shale zone within the member. The Parachute Creek member is about 457 m (1500 ft) thick beneath the USBM site.

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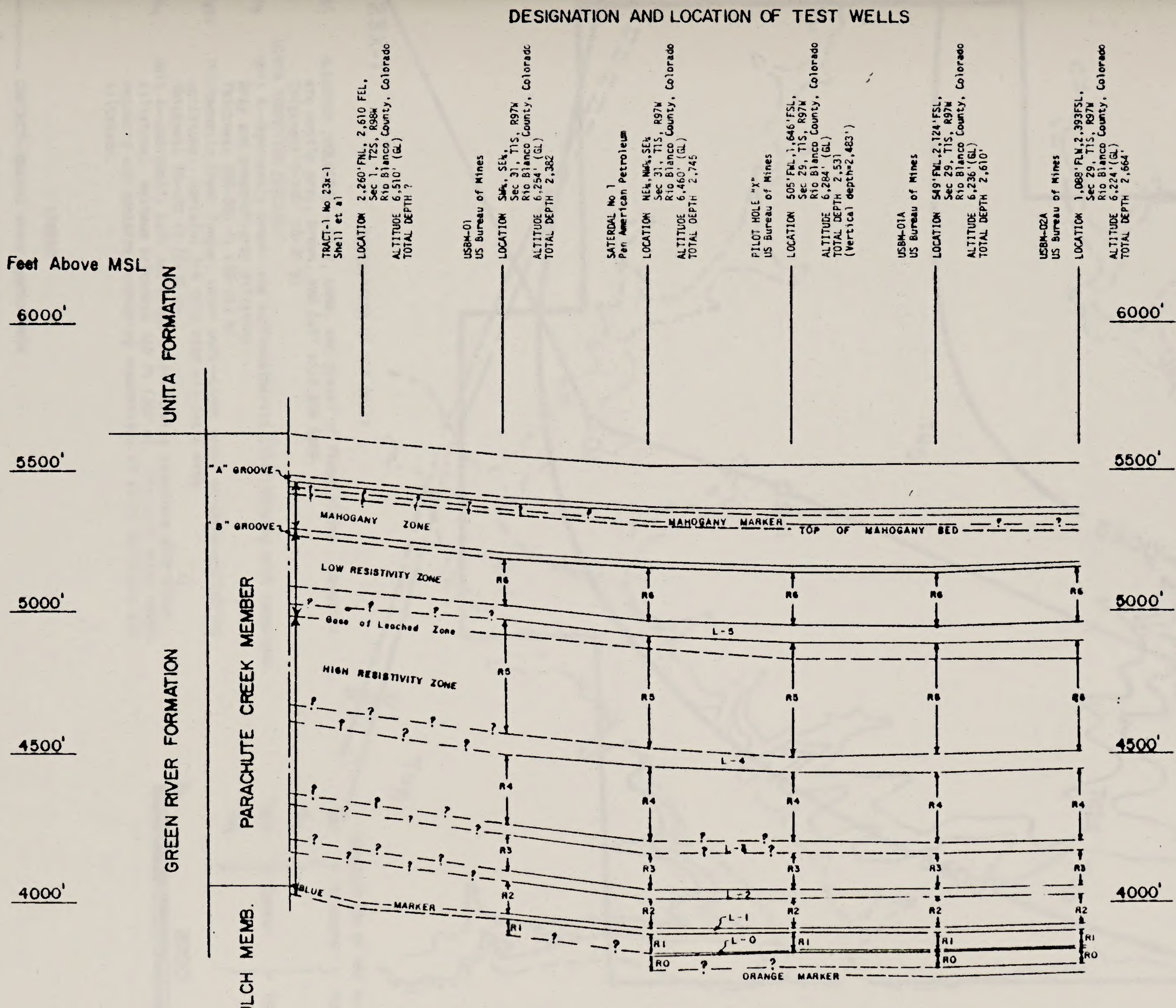
Colluvium consists of unconsolidated, heterogeneous masses of soil material and rock fragments.

4.4.2 Structural Geology of the Basin and Project Area

The Piceance Creek Basin is a northwest-trending structural downwarp which is asymmetric, with gently dipping limbs on the north and west

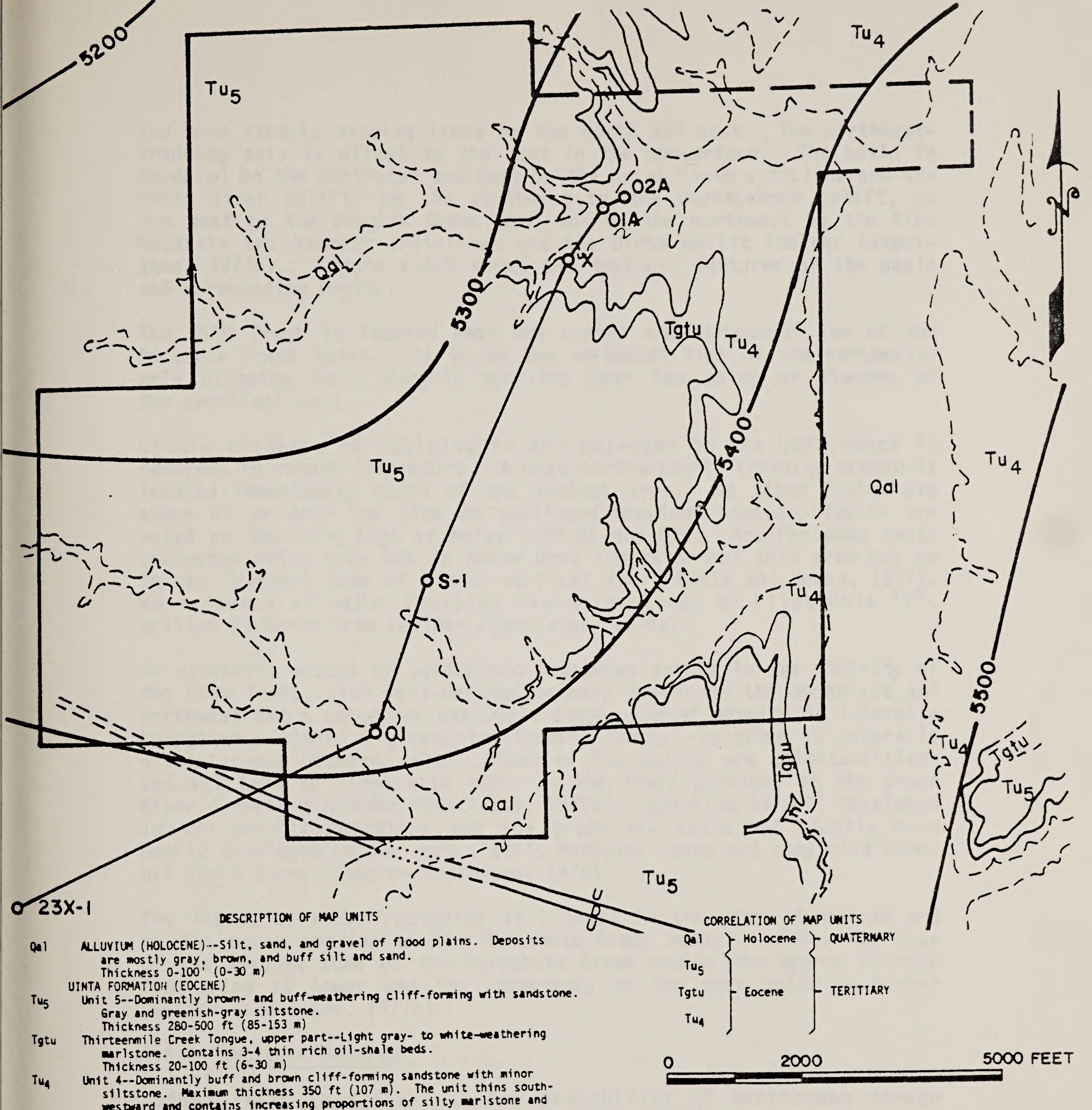


STRATIGRAPHIC CROSS SECTION
OF THE USBM TRACT

SOURCE : GOLDER ASSOCIATES, 1977b

NOTE : LOCATION OF CROSS SECTION IS ON FIGURE

FIGURE 4.4-1



DESCRIPTION OF MAP UNITS

Qal ALLUVIUM (HOLOCENE)--Silt, sand, and gravel of flood plains. Deposits are mostly gray, brown, and buff silt and sand. Thickness 0-100' (0-30 m)

UINTA FORMATION (EOCENE)

Tu_5 Unit 5--Dominantly brown- and buff-weathering cliff-forming with sandstone. Gray and greenish-gray siltstone. Thickness 280-500 ft (85-153 m)

Tgtu Thirteenmile Creek Tongue, upper part--Light gray- to white-weathering marlstone. Contains 3-4 thin rich oil-shale beds. Thickness 20-100 ft (6-30 m)

Tu_4 Unit 4--Dominantly buff and brown cliff-forming sandstone with minor siltstone. Maximum thickness 350 ft (107 m). The unit thins southwestward and contains increasing proportions of silty marlstone and siltstone.

CORRELATION OF MAP UNITS

Unit	Epoch	Period
Qal	Holocene	QUATERNARY
Tu_5	Eocene	TERITIARY
Tgtu		
Tu_4		

0 2000 5000 FEET

LEGEND

CONTACT--Dashed where approximate

U/D FAULT--Dashed where inferred; dotted where concealed. U, upthrown side; D, downthrown side

5500 STRUCTURE CONTOURS--Drawn on top of the Mahogany oil-shale zone of the Green River Formation. Contour interval 100 ft (30.5 m)

01 S-1 STRATIGRAPHIC CROSS SECTION LOCATION AND DRILL HOLES (Figure 2-7)

F F' ALLUVIAL CROSS SECTION LOCATIONS (Figure 2-8)

SURFICIAL GEOLOGY OF THE STUDY AREA

FIGURE 4.4-2

SOURCE: Duncan, D.C. 1976. Square S Ranch Quadrangle, Rio Blanco County, Colorado. U.S. Geol. Survey Misc. Field Studies Map MF-754.

and more steeply dipping limbs on the north and east. The northwest-trending axis is offset to the east in the subsurface. The basin is bordered on the northeast and east by the Axial basin anticline and the White River uplift, on the southwest by the Uncompahgre uplift, on the west by the Douglas Creek arch and on the northwest by the Blue Mountain and Rangely anticlines and the Uinta uplift (Golder Associates, 1977b). Figure 4.4-3 shows the tectonic features of the basin and surrounding region.

The USBM Tract is located near the center and structural low of the Piceance Creek basin. It is on the northeast limb of the northwesterly plunging South Rangely syncline near the point of flexure of the synclinal axis.

Little evidence of faulting in and adjacent to the USBM tract is recorded in recent literature. A west-northwesterly trending graben is located immediately south of the project area. No other faults are shown on or near the site on published mapping; however, faults are noted on the core logs of holes USBM-01 and 01A. Aquifer pump tests conducted using hole 02A in Horse Draw indicate that this area may be in the fracture zone of a near-vertical fault (Dale and Weeks, 1977). No evidence of major faulting was encountered by Pilot Hole "X", drilled in Horse Draw (Golder Associates, 1977a).

An extensive system of joints and fractures exists in the vicinity of the USBM Tract, with well-defined primary trends to the northeast and northwest and a secondary east-west trend. Joint density is laterally homogeneous within a given stratigraphic unit. Jointing is generally discontinuous between units. Some of the joints are calcite-filled, and all tend to close with depth in the lower portions of the Green River formation (Golder Associates, 1977b). Jointing is well developed in the brittle marlstone and low grade oil shale but usually more poorly developed in the more plastic Mahogany Ledge and some rich lower oil shale zones (Cameron Engineers, 1976).

The extent of rock fracturing is highest in the Uinta formation and in the upper portion of the Parachute Creek member. Below the base of the leached zone of the Parachute Creek member the degree of rock fracturing is lower and the competency of the rock units is higher (Golder Associates, 1977a).

4.4.4 Geologic Hazards

Seismic risk is defined as the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. The project area is located in a region where earthquakes of modified Mercalli Intensity VII or greater, and Richter Magnitude 5.0 or greater, occur with a frequency of one or fewer per decade, per square degree of surface area (Simon, 1972). The Piceance Creek Basin lies within a region of low seismicity. No

and more steeply dipping flanks on the north and south. The northwest-trending axis is offset to the east in the subsurface. The basin is bordered on the northeast and east by the Douglas Creek arch, and the White River uplift, on the southeast by the Grand Hogback (Hail, 1977), on the west by the Douglas Creek arch and on the northwest by the Axial Basin anticline and the Uinta uplift (Cameron Engineers, 1975b). Figure 4.4-2 shows the tectonic features of the basin and surrounding region.

The U-a/U-b Tract is located near the center and structural low of the Piceance Creek basin. It is on the northeast limb of the northwest-erly plunging Yellow Creek syncline near the north end of the basin at the synclinal axis.

Little evidence of faulting is seen adjacent to the U-a/U-b Tract as reported in recent literature. A northwest-southeasterly trending graben is located immediately south of the project area. No other faults are shown on or near the site on published mapping; however, faults are noted on the core logs of holes E-22-03 and U-4. Seismic profiles conducted using holes U-b, a north trend indicate that this area may be in the fracture zone of a near-vertical fault (Cole and Welder, 1977). No evidence of major faulting was encountered by Pilot Holes U-1 drilled in Horse Draw (Golder Associates, 1977a).

An extensive system of joints and fractured zones in the vicinity of the U-a/U-b Tract, with well-defined primary trends to the northwest and northeast and a secondary north-south trend. Joint density is laterally homogeneous within a given stratigraphic unit. Jointing is generally discontinuous between units. Some of the joints are partially filled and all tend to close with depth in the lower portions of the Green River Formation (Golder Associates, 1977a). Jointing is well developed in the brittle marlstone and the zones of rich oil shale but poorly developed in the more plastic leaching zones and the more lean oil shale zones (Cameron Engineers, 1975).

The extent of rock fracturing is greatest in the Uinta Formation and in the upper portion of the Parachute Creek member. Below the base of the leached zone of the Parachute Creek member the degree of rock fracturing is lower and the competency of the rock units is higher (Golder Associates, 1977a).

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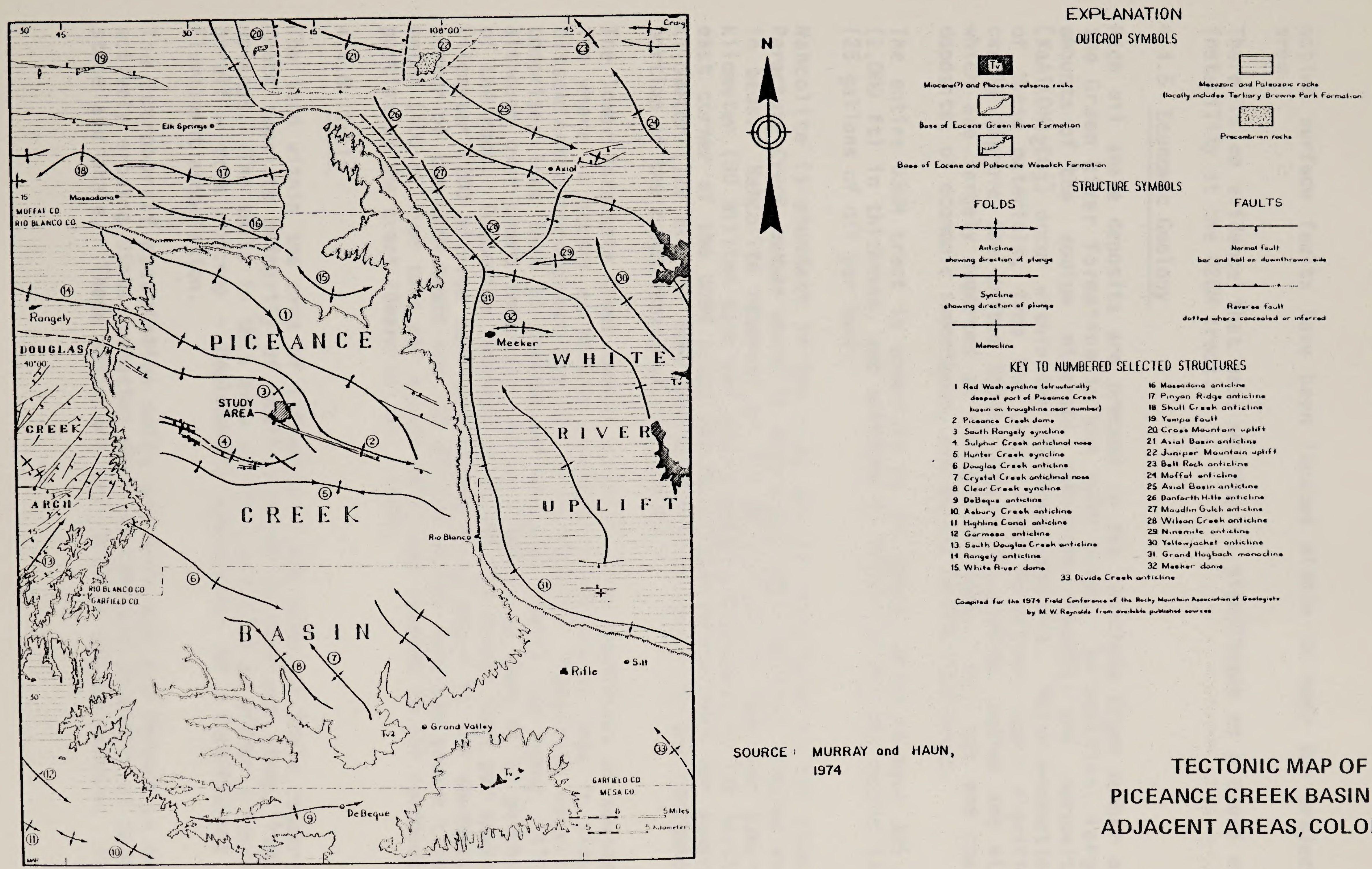
Seismic risk is defined as the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. The project area is located in a region where earthquakes of modified Mercalli intensity VII or greater, and Richter magnitudes 5.0 or greater, occur with a frequency of one or fewer per decade, per square degree of surface area (Algermissen, 1969). The Piceance Creek Basin lies within a region of low seismicity. As



SOURCE: MURRAY and HAUN, 1974

TECTONIC MAP OF PICEANCE CREEK BASIN AND ADJACENT AREAS, COLORADO

FIGURE 4.4-3

active surface faults have been located within or near the project area.

There is no evidence that mass wasting is significant as a cause of instability at the USBM tract.

4.4.5 Economic Geology

Rich oil shale deposits are present in the Parachute Creek member of the Green River formation in the USBM tract. In addition, large amounts of the sodium minerals nahcolite ($NaHCO_3$) and dawsonite [$NaAl(OH)_2CO_3$] occur within the oil shale deposits. Major production of these materials, from the Green River formation, could significantly improve the United States supply of alumina, sodium and oil which are largely imported at the present time. Oil, gas and coal deposits, of economic importance, are absent in the USBM tract.

The entire USBM tract is underlain by oil shale, which is over 305 m (1,000 ft) in thickness, and averages 83 liters of oil per metric ton (25 gallons of oil per ton).

Nahcolite is abundant in the area and is restricted to the lower Parachute Creek member where it occurs both as individual nodules and in beds. Nahcolite reserves of 2.8 million metric tons per square kilometer (80 million tons per square mile) are present in the southeast corner of the USBM tract and 42 million metric tons per square kilometer (120 million tons per square mile) occur in the northwest portion of the tract (Beard et. al., 1974).

The lower Parachute Creek member contains large quantities of dawsonite where it occurs as minute crystals, 5 microns or less in size, disseminated throughout the oil shale matrix. Dawsonite usually comprises less than 10 percent of the rock (Smith and Young, 1970) although over short intervals, it may compose as much as 25 percent of the rock. Dawsonite reserves of 70 million metric tons per square kilometer (200 million tons per square mile) occur in the southeast corner of the USBM tract and 140 million metric tons per square kilometer (400 million tons per square mile) are present in the northwest portion of the tract (Beard et, al., 1974).

4.4.6 Soils

The land within the area of influence of the USBM Oil Shale research tract consists primarily of small alluvial valleys and steep, rocky uplands. The soils in this area can be classified as either a Eutroboralf - rock outcrop - Haploborall association or a Ustifluvent - Fluvaquent association.

The Eutroboralf association soils are thin and are formed on the actively eroding Uinta formation which is composed primarily of sandstone and shale. These soils are well drained and calcareous. The

active surface faults have been located within or near the project area.

There is no evidence that salt washing is significant as a cause of instability at the U-a/U-b tract.

4.4.5 Economic Geology

Rich oil shale deposits are present in the Parachute Creek member of the Green River Formation in the U-a/U-b tract. In addition, large amounts of two sodium minerals, nahcolite (NaHCO$_3$) and dawsonite [NaAl(OH)$_2$CO$_3$], occur within the oil shale deposits. Major production of these materials, from the Green River Formation, could significantly improve the United States supply of alumina, sodium and oil which are already imported at the present time. Oil, gas and coal deposits, of economic importance, are absent in the U-a/U-b tract.

The entire U-a/U-b tract is underlain by oil shale, which is over 305 m (1,000 ft) in thickness, and averages 93 liters of oil per metric ton (25 gallons of oil per ton).

Nahcolite is abundant in the area and is restricted to the lower Parachute Creek member where it occurs both as individual nodules and in beds. Nahcolite reserves of 3.8 million metric tons per square kilometer (10 million tons per square mile) are present in the northeast corner of the U-a/U-b tract and 45 million metric tons per square kilometer (125 million tons per square mile) occur in the northwest portion of the tract (Beard et al., 1974).

The lower Parachute Creek member contains large quantities of dawsonite where it occurs as minute crystals, 5 microns or less in size, disseminated throughout the oil shale matrix. Dawsonite usually comprises less than 10 percent of the rock matrix and layers, though, although over short intervals, it may comprise as much as 25 percent of the rock. Dawsonite reserves of 70 million metric tons per square kilometer (200 million tons per square mile) occur in the southeast corner of the U-a/U-b tract and 180 million metric tons per square kilometer (500 million tons per square mile) are present in the northwest portion of the tract (Beard et al., 1974).

4.4.6 Soils

The land within the area of influence of the U-a/U-b oil shale research tract consists primarily of gently sloping uplands, the plains, rocky uplands. The soils in this area can be classified as either a Natrargid - rock outcrop - Torriorthent association, or a Haplargid - Fluvaquent association.

The Natrargid association soils are fairly deep and are formed on the actively weathering Uinta Formation which is composed primarily of sandstone and shale. These soils are well drained and calcareous. The

Eutroboralfs are vegetated by range plants and by pinyon-juniper but are highly vulnerable to disturbance and erosion. Even minor disruption of the native plant cover will cause a considerable soil loss from both wind and water erosion. Upland soils range in composition from sandy loam to silt loam, with varying percentages of larger fragments included.

The Ustifluvent association is composed of soils developed from alluvial material. These are generally cool, deep and moderately deep soils. They are well drained to poorly drained and are level or very gently dipping. Texturally the Ustifluvents are moderately coarse to moderately fine. In the narrow tributary valleys of the Piceance Creek valley such as Horse Draw, the alluvial areas are vegetated with typical range plant associations; where topography and water availability permit, the alluvial soils are useful for raising hay crops. Ustifluvents are susceptible to sheet erosion, gullying and channel erosion, more because of the aspect than because of inherent properties.

The following are the soil series described and mapped by an U.S. Soil Conservation Service representative in the area of influence. The listing includes areas which are primarily bedrock or shallow to bedrock. The distribution of soil types is shown on Figure 4.4-4. The chemical composition for several of these soil types is tabulated in Appendix C.

Rivra Series

The surface horizon of Rivra soils is typically a channery loamy fine sand about 15 cm (6 in.) thick, with weak fine granular structure and moderate alkalinity.

The intermediate horizon of moderate alkalinity is from 25 cm (10 in.) to 101 cm (40 in.) in depth, and is composed of 35 to 50 percent coarse fragments. Rivra association soils are high in permeability but low in water holding capacity and percent organic matter. Surface runoff is generally moderate, and soils have a medium erosion potential.

Rentsac Series

Rentsac soils are shallow and well drained soils, mainly formed on upland sandstones of the Uinta formation. The soil is generally pale brown and very channery throughout, usually overlying hard, fractured sandstone. The bulk of the soil is slightly to moderately alkaline, has high permeability, moderate surface runoff and moderate erosion potential. Soil depth averages about 51 cm (20 in.) and slope varies between 5 and 50 percent. These soils have medium organic matter content in the surface horizon.

Torriorthents are vegetated by range plants and by pinyon-juniper but are highly vulnerable to disturbance and erosion. Poor range management of the native plant cover will cause Torriorthents soil loss from both wind and water erosion. Surface soils range in composition from sandy loam to silt loam, with varying percentages of larger fragments included.

The Ustifluvents association is composed of soils developed from alluvial material. These are generally sands, loams and moderately deep soils. They are well drained to poorly drained and are level or very gently sloping. Textures of the Ustifluvents are moderately coarse to moderately fine. In the narrow, incised valleys of the Piceance Creek valley such as Horse Draw, the alluvial areas are vegetated with typical range plant associations, where topography and water availability permit, the alluvial soils are useful for raising hay crops. Ustifluvents are susceptible to sheet erosion, gullying and channel erosion, more because of the aspect than because of inherent properties.

The following are the soil series described and mapped by the U.S. Soil Conservation Service representatives in the area of the Tract. The listing includes areas which are primarily bedrock or shallow to bedrock. The distribution of soil types is shown on Figure 3.4-4. The chemical composition for several of these soil types is tabulated in Appendix 3.

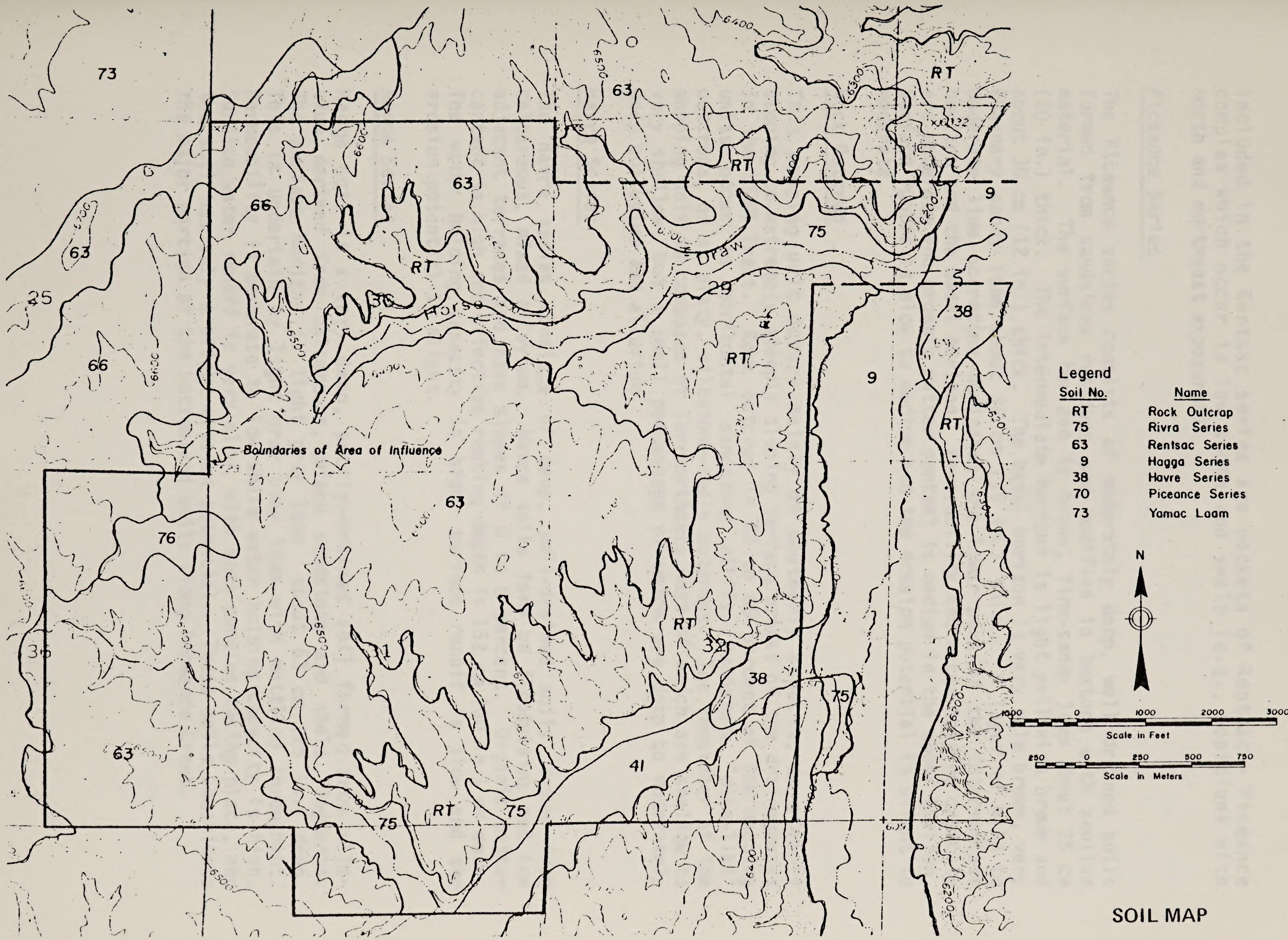
Rivra Series

The surface horizon of Rivra soils is typically a channery, loamy fine sand about 15 cm (6 in.) thick, with weak fine granular structure and moderate alkalinity.

The intermediate horizon of moderate alkalinity is from 15 cm (6 in.) to 101 cm (40 in.) in depth, and is composed of 35 to 50 percent coarse fragments. Rivra association soils are high in permeability but low in water holding capacity and percent organic matter. Surface runoff is generally moderate, and soils have a medium erosion potential.

Rentsac Series

Rentsac soils are shallow and well drained soils, mainly formed on colluvial sandstones of the Uinta Formation. The soil is generally pale brown and very channery throughout, usually overlying hard, fractured sandstone. The bulk of the soil is slightly to moderately alkaline, has high permeability, moderate surface runoff and moderate erosion potential. Soil depth averages about 51 cm (20 in.) and slope varies between 5 and 50 percent. These soils have medium organic matter content in the surface horizon.



SOIL MAP

FIGURE 4.4-4

Included in the Rentsac series are pockets of Rentsac - Piceance complex which occur in low spots and swale (e.g., positions with north and northeast exposures).

Piceance Series

The Piceance series consists of moderately deep, well drained soils formed from sandstone residues and modified in texture with aeolian material. The surface horizon is brown, fine-sandy loam about 25 cm (10 in.) thick. The intermediate horizon is light yellowish brown and about 30 cm (12 in.) thick. The basal horizon is very pale brown, very channery sandy loam about 38 cm (15 in.) thick. A layer of mild to moderate lime accretion dominates the lower part of the intermediate horizon and the basal horizon. Permeability and water holding capacity are moderate and organic matter content is medium in the upper horizon. Surface runoff is slow to medium and the erosion potential is slight to moderate.

Rock Outcrop

This mapping unit occurs mainly on southerly aspects, on steeply sloping to extremely steeply sloping terrace breaks of the drainageways in the USBM Tract. Rock outcrop in 50 to 60 percent of the mapping units occur as horizontal sandstone cliffs, sandstone "dike-like" outcrops, or as platy, siltstone-shale outcrops. The remainder of the mapping unit is composed of Torriorthents most of which are shallow to very shallow, but a small percentage of which are deep to moderately deep colluvium and alluvium.

Havre Series

The Havre series consists of deep, well-drained soils formed from calcareous, mixed alluvium. Havre soils form on floodplains and low adjacent terraces and have slopes of 0 to 8 percent. Organic matter content is high and effective rooting depth is 152 cm (60 in.) or more. The water holding capacity is high, surface runoff is slow and the erosion potential is slight.

Hagga Series

Hagga soil is a very deep, poorly-drained soil formed from alluvium derived from calcareous, mixed sandstone and shale fragments. The surface horizon is light gray loam about 63 cm (25 in.) deep. This is underlain by light gray clay loam with mottling throughout. Permeability is moderate to low while water holding capacity is high. Surface water runoff is very slow, with some ponding taking place, and the soil has only a slight erosion potential. These soils constitute the major portion of the bottomland soils along Piceance Creek.

Included in the Rentsch series are pockets of Rentsch - Piceance complex which occur in low spots and swale (e.g., positions with north and northeast exposures).

Piceance Series

The Piceance series consists of moderately deep, well drained soils formed from sandstone residuum and modified in texture with eolian material. The surface horizon is brown, fine sandy loam about 25 cm (10 in.) thick. The intermediate horizon is light yellowish brown and about 30 cm (12 in.) thick. The basal horizon is very pale brown, very channery sandy loam about 30 cm (12 in.) thick. A layer of mild to moderate lime accumulation underlies the lower part of the intermediate horizon and the basal horizon. Permeability and water holding capacity are moderate and organic matter content is medium in the upper horizon. Surface runoff is slow to medium and the erosion potential is slight to moderate.

Rock Outcrop

This mapping unit occurs mainly on southerly aspects, on strongly sloping to extremely steeply sloping terrace breaks of the [illegible] in the USGS Tract. Rock occupies 50 to 90 percent of the mapping units, occur as horizontal sandstone cliffs, sandstone "slip rock" outcrops, or as pitty, siltstone-shale outcrops. The remainder of the mapping unit is composed of Torriorthents most of which are shallow to very shallow, but a small percentage of which are deep to moderately deep colluvium and alluvium.

Havre Series

The Havre series consists of deep, well-drained soils formed from calcareous, mixed alluvium. Havre soils form on floodplains and low adjacent terraces and have slopes of 0 to 8 percent. Organic matter content is high and effective rooting depth is 152 cm (60 in.) or more. The water holding capacity is high, surface runoff is slow and the erosion potential is slight.

Hagga Series

Hagga soil is a very deep, poorly-drained soil formed from silty alluvium derived from calcareous, mixed sandstone and shale fragments. The surface horizon is light gray loam about 41 cm (16 in.) deep. This is underlain by light gray clay loam with mottling throughout. Permeability is moderate to low while water holding capacity is high. Surface water runoff is very slow, with some ponding taking place, and the soil has only a slight erosion potential. These soils constitute the major portion of the bottomland soils along Piceance Creek.

Yamac Loam Series

Yamac loam is a deep, well-drained soil typically found on rolling uplands and ridges and formed from alluvial and aeolian materials. The entire column, to 152 cm (60 in.) or more, is composed of grayish brown to brown loam. Included in this unit are small areas of Forelle and Piceance, both having slopes of 5 to 15 percent. Also included are some small natric areas of 3 m (10 ft) to 15 m (50 ft) diameter. Permeability of Yamac soil is moderate and water holding capacity is high. Surface runoff is slow, the erosion potential is slight, and the amount of organic matter in the surface horizon is moderate.

4.5 Surface Hydrology

The USBM Oil Shale Research Facility site is located in the drainages of Ryan Gulch and Horse Draw, tributaries of Piceance Creek. Horse Draw, an ephemeral stream, drains the site area.

As shown on Figure 4.5-1, the northerly portion of the Piceance Creek Basin is comprised of the watersheds drained by Piceance and Yellow Creeks. The combined watersheds have an area of 2311 km^2 (892 sq mi) and receive an average annual precipitation of 36.8 cm (14.5 in). Vegetation varies from desert-shrub at lower elevations to forest at higher elevations. Precipitation amounts received annually increase with increasing elevation. Available surface water resources in the Piceance Creek Basin are fully developed for the irrigation of approximately 2141 hectares (5300 ac) of pasture and hay meadow. Piceance Creek and a few of its major tributaries are perennial streams. Insufficient data are available to determine whether or not Yellow Creek is perennial. A water balance calculated by Wymore (1974) indicates 98% of the precipitation in the Piceance Creek basin is consumed by evapotranspiration. The remainder contributes to streamflow. Ground water recharge from precipitation is balanced with discharge to perennial streams and evapotranspiration.

4.5.1 Local Drainages

Existing stream flow conditions and the effects of oil shale resource development are being monitored in the area influenced by the development of the USBM site. U.S. Geological Survey (see Figure 4.5-1) stream gages are located on Piceance Creek below Ryan Gulch (09306200) and near Rangely (09306210) below Horse Draw and provide baseline data for Piceance Creek. A stream gage located on Piceance Creek near the White River (09306222) provides data downstream from the USBM tract. The U.S. Geological Survey (USGS) gaging stations on Black Sulphur Creek near Rio Blanco (09306061) and Hunter Creek (09306175) provide data from sections of the drainage basin upstream of the USBM tract. Appendix D contains hydrographs of mean daily discharge for typical water years 1974, 1975, and 1976 for each of these four stream gages.

Tebec Loam Series

Tebec loam is a deep, well-drained soil generally found on rolling uplands and ridges and formed from alluvial and aeolian materials. The entire column, to 152 cm (60 in.) or more, is composed of grayish brown to brown loam. Included in this soil are small areas of Forelle and Piceance, both having slopes of 3 to 15 percent. Also included are some small [illegible] areas of [illegible]. Permeability of Tebec soil is moderate and water holding capacity is high. Surface runoff is slow, the erosion potential is slight, and the amount of organic matter in the surface horizon is moderate.

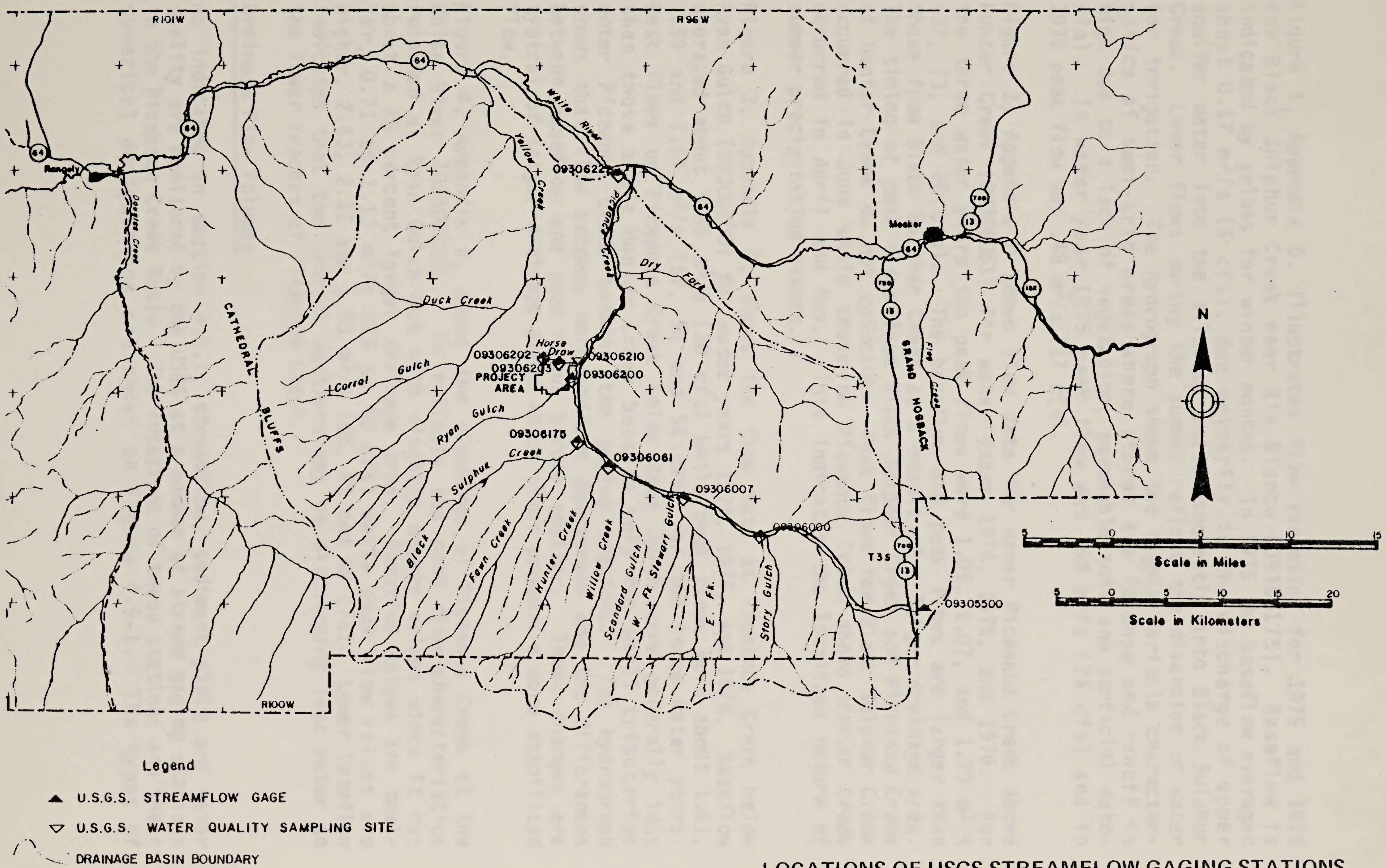
4.5 Surface Hydrology

The USGM Oil Shale Research Facility site is located in the drainages of Ryan Gulch and Horse Draw, tributaries of Piceance Creek. Horse Draw, an ephemeral stream, drains the site area.

As shown on Figure 4.5-1, the northerly portion of the Piceance Creek Basin is comprised of the watersheds drained by Piceance and Yellow Creeks. The combined watersheds have an area of [illegible] km² ([illegible] mi²) and receive an average annual precipitation of [illegible] cm ([illegible] in.). Vegetation varies from desert-shrub at lower elevations to forest at higher elevations. Precipitation amounts received generally increase with increasing elevation. Available surface water supplies in the Piceance Creek Basin are fully developed for the irrigation of approximately 2101 hectares (5200 ac) of pasture and hay meadows. Piceance Creek and a few of its major tributaries are perennial streams. Insufficient data are available to determine whether or not Yellow Creek is perennial. A water balance calculated by Weeks (1974) indicates 90% of the precipitation in the Piceance Creek Basin is consumed by evapotranspiration. The remainder contributes to streamflow. Ground water recharge from precipitation is balanced by discharge to perennial streams and evapotranspiration.

4.5.1 Local Drainages

Existing stream flow conditions and the effects of oil shale resource development are being monitored in the area influenced by the development of the USGM site. U.S. Geological Survey (see Figure 4.5-1) stream gages are located on Piceance Creek below Ryan Gulch (09306200) and near Rangely (09306222) below White River and provide baseline data for Piceance Creek. A stream gage located on Piceance Creek near the White River (09306222) provides data downstream from the USGM tract. The U.S. Geological Survey (USGS) gaging stations on Black Sulphur Creek near Rio Blanco (09306061) and Hunter Creek (09306128) provide data from sections of the drainage basin upstream of the USGM tract. Appendix D contains hydrographs of mean daily discharge for typical water years 1974, 1975, and 1976 for each of these four stream gages.



LOCATIONS OF USGS STREAMFLOW GAGING STATIONS AND WATER QUALITY SAMPLING SITES

FIGURE 4.5-1

Figure 1, Appendix D, illustrates flow variation for 1975 and 1976 for Black Sulphur Creek near Rio Blanco (09306175). Baseflow is indicated by values for winter months. In 1975 the baseflow averaged about 0.17 m^3/s (6 cfs), due primarily to the discharge of upper aquifer water into the alluvium and consequently into Black Sulphur Creek. Lower flows during the summer reflect the diversion of water for irrigation. The hydrograph shows the highly variable characteristics of semi-arid areas where storms are intense and runoff is high due to a lack of vegetation, permeable soil and surficial material. In water year 1975 peak flow was .68 m^3/s (24 cfs) and in 1976 peak flow was .48 m^3/s (17 cfs).

Figure 2, Appendix D shows flow data for upper Piceance Creek above Hunter Creek (09306061) for water years 1974, 1975, and 1976. For the three water years the peak flows were 1.05, 2.07, and 1.70 m^3/s (37, 73, and 60 cfs). The baseflow and peak flows are larger than those from Black Sulphur Creek as a result of a larger drainage area. The timing of peak flows from Black Sulphur Creek and Piceance Creek at Hunter Creek do not coincide. Peak flows for Black Sulphur Creek occurred in June while those on Piceance Creek above Hunter Creek occurred in April and May. This indicates the localized nature of summer precipitation events.

Figure 3, Appendix D, shows the flow data at Piceance Creek below Ryan Gulch (09306200) for water years 1974, 1975, and 1976. Baseflow averaged about 9.85 m^3/s (30 cfs) while peak flows were about 1.61, 1.59 and 1.59 m^3/s (57, 56 and 56 cfs) for the three water years. Peak flows on Piceance Creek below Ryan Gulch were generally less than those above Hunter Creek because only two small tributaries enter Piceance Creek between the gaging stations. The hydrograph shows that flow becomes more uniform downstream and the differences between baseflow and peak flows become smaller. These changes are typical of larger drainage areas which often produce a more stabilized flow.

Figure 4, Appendix D, shows the discharge of Piceance Creek at the White River (09306222). It reflects the same flow characteristics recorded at Ryan Gulch but with slightly higher values since it has about a 25 percent larger drainage area. Baseflow values are smaller, 0.71 to 1.13 m^3/s (25 to 40 cfs) while peak flow values are higher, 2.43, 2.32 and 1.93 m^3/s (86, 82 and 68 cfs). Lower baseflow indicates that the bedrock aquifers may be discharging less water to the lower reaches of Piceance Creek.

Drainage Flow Volumes

As indicated in section 4.5.1, streamflow, sediment yield and water quality are monitored by the USGS at a number of stream gaging stations in the Piceance Creek Basin. The locations of these stations and their numerical designations are shown on Figure 4.5-1. The types of

Figure 1, Appendix D, illustrates flow variation for 1975 and 1976 for Black Sulphur Creek near Rio Blanco (09306175). Baseflow is indicated by values for winter months. In 1975 the baseflow averaged about 0.17 m³/s (6 cfs), due primarily to the discharge of upper aquifer water into the alluvium and consequently into Black Sulphur Creek. Lower flows during the summer reflect the diversion of water for irrigation. The hydrograph shows the highly variable characteristics of semi-arid areas where storms are intense and runoff is high due to a lack of vegetation, permeable soil, and surficial materials. In water year 1975 peak flow was 3.80 m³/s (134 cfs) and in 1976 peak flow was 0.48 m³/s (17 cfs).

Figure 2, Appendix D shows flow data for upper Piceance Creek above Hunter Creek (09306007) for water years 1974, 1975, and 1976. For the three water years the peak flows were 1.06, 2.07, and 1.70 m³/s (37, 73, and 60 cfs). The baseflow and peak flows are larger than those from Black Sulphur Creek as a result of a larger drainage area. The timing of peak flows from Black Sulphur Creek and Piceance Creek at Hunter Creek do not coincide. Peak flows for Black Sulphur Creek occurred in June while those on Piceance Creek above Hunter Creek occurred in April and May. This indicates the localized nature of summer precipitation events.

Figure 3, Appendix D, shows the flow data at Piceance Creek below Ryan Gulch (09306200) for water years 1974, 1975, and 1976. Baseflow averaged about 0.28 m³/s (10 cfs) while peak flows were about 1.61, 1.60 and 1.39 m³/s (57, 56 and 49 cfs) for the three water years. Peak flows on Piceance Creek below Ryan Gulch were generally less than those above Hunter Creek because only two small tributaries enter Piceance Creek between the gaging stations. The hydrograph shows that flow becomes more uniform downstream and the difference between baseflow and peak flows become smaller. These changes are typical of larger drainage areas which often produce a more stabilized flow.

Figure 4, Appendix D, shows the discharge of Piceance Creek at the White River (09306222). It exhibits the same flow characteristics recorded at Ryan Gulch but with slightly higher values since it has about a 25 percent larger drainage area. Baseflow values are smaller, 0.23 to 0.12 m³/s (8 to 4 cfs) while peak flow values are higher, 2.43, 2.12 and 1.37 m³/s (86, 75 and 48 cfs). Lower baseflow indicates that the lower aquifer may be discharging less water to the lower reaches of Piceance Creek.

Drainage Flow Volumes

As indicated in section 4.5.1, streamflow, sediment yield and water quality are monitored by the USGS at a number of stream gaging stations in the Piceance Creek Basin. The locations of these stations and their numerical designations are shown on Figure 4.5-1. The types of

measurements and sampling conducted at each station are summarized in Table 4.5-1.

The seasonal distribution of streamflow in the Piceance Creek basin is typical of high elevation watersheds in Colorado. These watersheds accumulate a snowpack during the winter, which provides most of the annual streamflow during early spring as the snowpack melts. Ground water discharged to the streams provides most of the streamflow during the remainder of the year. At lower elevations, diversions for irrigation can have a pronounced effect on streamflow distribution.

The above concepts (Weeks et al, 1976) are illustrated in Figures 4.5-2 and 4.5-3 which show the hydrographs of minimum, maximum and average monthly streamflow measured at gaging stations located on Piceance Creek at Rio Blanco (09305500) and below Ryan Gulch (09306200), respectively. The station located at Rio Blanco is high on Piceance Creek, above irrigation diversions. Piceance Creek drains 23 km^2 (9 sq mi) above the station. The hydrograph for this station shows approximately 75 percent of the annual streamflow occurs from April through June which corresponds with melting of the snowpack. During July through September streamflow consists of ground water discharge and runoff from precipitation. The winter streamflow consists of ground water discharge.

The hydrograph for the station located on Piceance Creek below Ryan Gulch shows the effect of irrigation diversions. This station is located near the USBM Research tract at a much lower elevation than the station at Rio Blanco. Piceance Creek drains 1256 km^2 (485 sq mi) above the lower station. The hydrograph shows depressions of streamflow during April and June through July which result from diversions for irrigation. Runoff from precipitation is evident in the secondary flow peak which occurs during August.

An analysis of stream gaging records by Weeks, et. al. (1974) indicates that the average annual streamflow in Piceance Creek at its confluence with the White River from 1965 through 1973 was approximately 17.9 hm^3 (14,520 ac-ft).

<u>Water Quality</u>

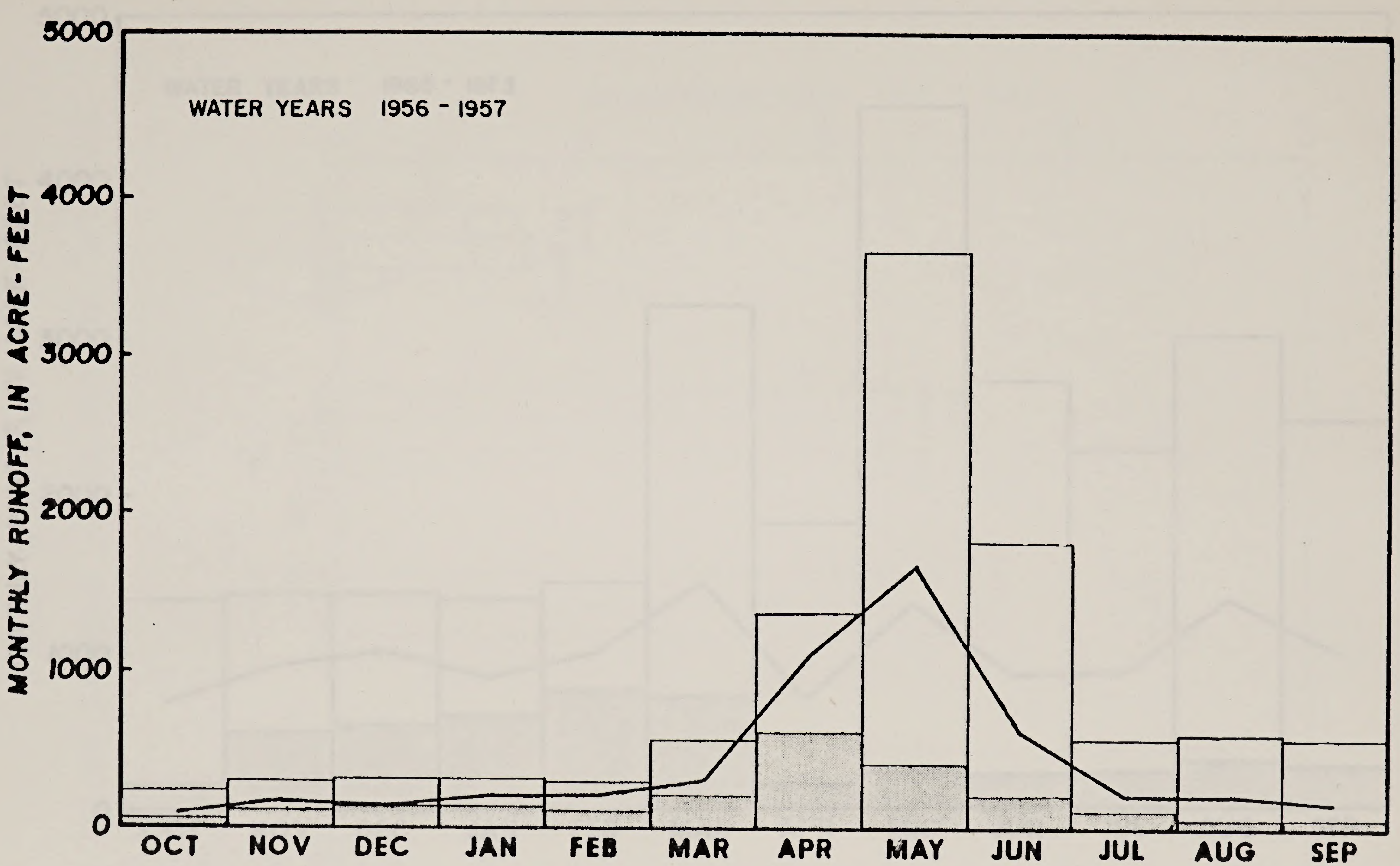
Water quality in the Piceance Creek drainage can be classified as mixed bicarbonate type in the upper reaches and sodium bicarbonate type in the lower reaches. Water quality in Piceance Creek is poor and tends to deteriorate downstream as shown in Figure 4.5-4. Water sampling indicates that USPHS drinking water standards of Piceance Creek are exceeded by concentrations of fluoride, cadmium, and chromium. Chemical constituents detected in the Piceance Creek surface water can be attributed to weathering processes acting on surficial materials. Many constituents are more highly concentrated because of

TABLE 4.5-1

SELECTED U.S. GEOLOGICAL SURVEY GAGING STATIONS
IN THE PICEANCE CREEK BASIN

Downstream Order Number Name and Location	Measurements: Flow	Sediment	Water Quality	Period of Flow Record	Drainage Area
09306222 Piceance Creek at White River	X	X	X	10/64 - 9/66, 10/70 -	1632 km^2 (630 mi^2)
09306210 Piceance Creek near White River			X	12/70 - 9/76	1282 km^2 (495 mi^2)
09306203 Horse Draw at mouth near Rangely	X	X	X	10/78 -	
09306202 Horse Draw near Rangely	X	X	X	10/78 -	
09306200 Piceance Creek below Ryan Gulch	X	X	X	10/64 -	1256 km^2 (485 mi^2)
09306175 Black Sulpher Creek near Rio Blanco	X	X	X	12/74 -	267 km^2 (103 mi^2)
09306061 Piceance Creek above Hunter Creek	X	X	X	4/74 -	800 km^2 (309 mi^2)
09306007 Piceance Creek below Rio Blanco	X	X	X	4/74 -	458 km^2 (177 mi^2)
09306000 Piceance Creek near Rio Blanco	X			10/40 - 9/43	396 km^2 (153 mi^2)
09305500 Piceance Creek at Rio Blanco	X			10/55 - 9/57	23 km^2 (9 mi^2)

Source: USGS

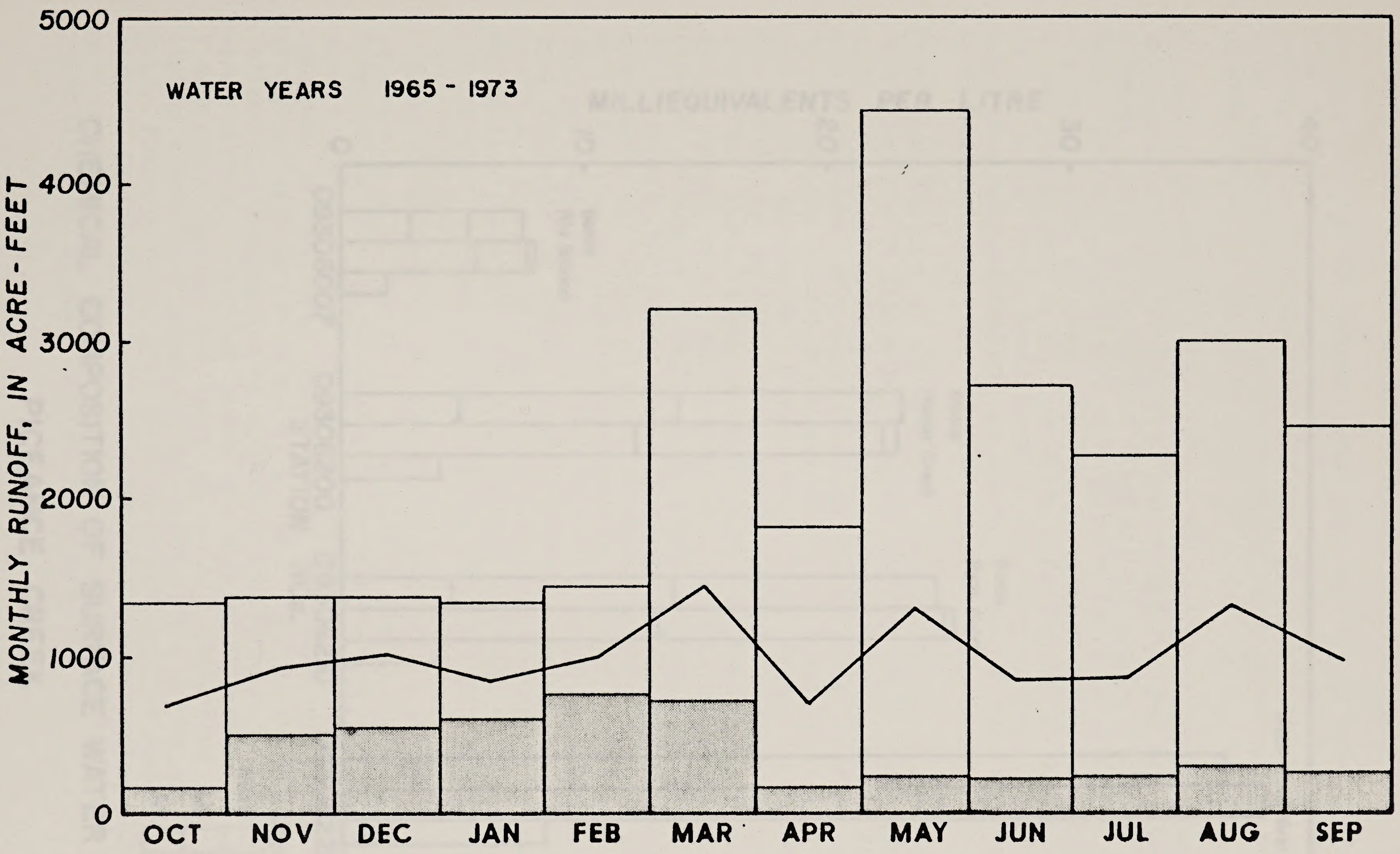


MEAN, MAXIMUM, AND MINIMUM RUNOFF

PICEANCE CREEK AT RIO BLANCO (09305500)

SOURCE : WEEKS, ET. AL., 1974

FIGURE 4.5-2



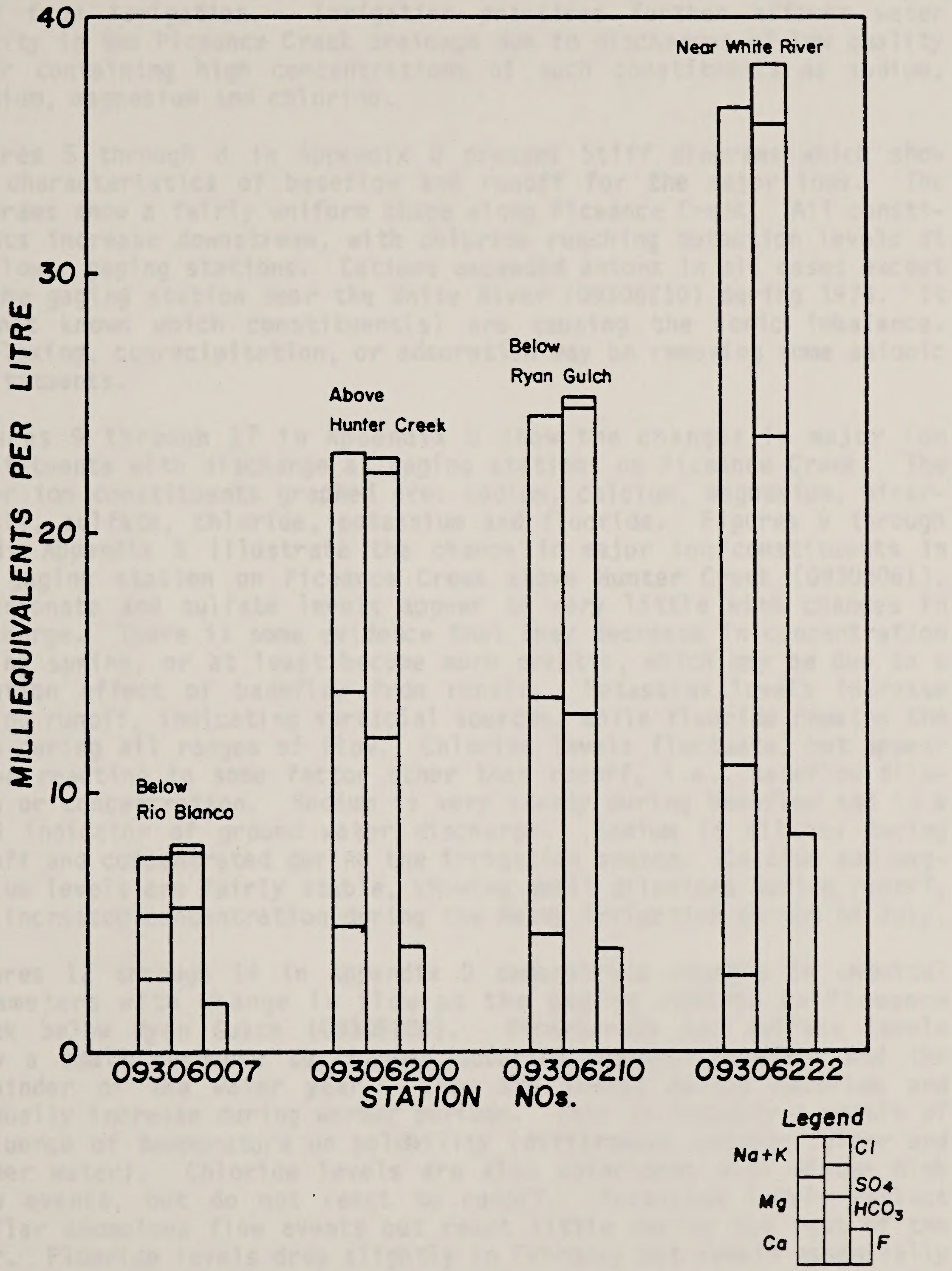
MEAN, MAXIMUM, AND MINIMUM RUNOFF

PICEANCE CREEK BELOW RYAN GULCH (09306200)

SOURCE: WEEKS, ET. AL., 1974

FIGURE 4.5-3

vtn



CHEMICAL COMPOSITION OF SURFACE WATER ALONG

PICEANCE CREEK

JULY - AUGUST, 1973

SOURCE: WEEKS, et. al., 1974

FIGURE 4.5-4

seepage of high TDS ground water into the stream system, and return flow from irrigation. Irrigation practices further affects water quality in the Piceance Creek drainage due to discharges of low quality water containing high concentrations of such constituents as sodium, calcium, magnesium and chloride.

Figures 5 through 8 in Appendix D present Stiff diagrams which show the characteristics of baseflow and runoff for the major ions. The diagrams show a fairly uniform shape along Piceance Creek. All constituents increase downstream, with chloride reaching detection levels at the lower gaging stations. Cations exceeded anions in all cases except at the gaging station near the White River (09306210) during 1974. It is not known which constituent(s) are causing the ionic imbalance. Complexing, coprecipitation, or adsorption may be removing some anionic constituents.

Figures 9 through 17 in Appendix D show the changes in major ion constituents with discharge at gaging stations on Piceance Creek. The major ion constituents graphed are: sodium, calcium, magnesium, bicarbonate, sulfate, chloride, potassium and fluoride. Figures 9 through 11 in Appendix D illustrate the change in major ion constituents in the gaging station on Piceance Creek above Hunter Creek (09306061). Bicarbonate and sulfate levels appear to vary little with changes in discharge. There is some evidence that they decrease in concentration during spring, or at least become more erratic, which may be due to a dilution effect of baseflow from runoff. Potassium levels increase during runoff, indicating surficial sources, while fluoride remains the same during all ranges of flow. Chloride levels fluctuate, but appear to be reacting to some factor other than runoff, i.e., baseflow dilution or concentration. Sodium is very steady during baseflow and is a good indicator of ground water discharge. Sodium is diluted during runoff and concentrated during the irrigation season. Calcium and magnesium levels are fairly stable, showing small dilutions during runoff, and increased concentration during the heavy irrigation period of July.

Figures 12 through 14 in Appendix D demonstrate changes in chemical parameters with change in flow at the gaging station on Piceance Creek below Ryan Gulch (09306200). Bicarbonate and sulfate levels show a small response to changes occuring between baseflow and the remainder of the water year. They are lowest during baseflow and gradually increase during warmer periods. This is probably a result of influence of temperature on solubility (differences between colder and warmer water). Chloride levels are also coincident with winter high flow events, but do not react to runoff. Potassium levels reflect similar anomolous flow events but react little during the rest of the year. Fluoride levels drop slightly in February but remain essentially stable. Sodium levels are coincident with the irrigation season, being more concentrated during the spring and summer. Calcium and magnesium react little to seasonal changes at station 200.

seepage of high TDS ground water into the stream system, and return flow from irrigation. Irrigation practices further affects water quality in the Pitchfork Creek drainage due to discharge of low quality water containing high concentrations of such constituents as sodium, calcium, magnesium and chloride.

Figures 5 through 8 in Appendix D present Stiff diagrams which show the characteristics of baseflow and runoff for the major ions. The diagrams show a fairly uniform shape along Pitchfork Creek. All constituents increase downstream, with chloride reaching detection levels at the lower gaging stations. Cations exceeded anions in all cases except at the gaging station near the White River ([illegible]) during 1974. It is not known which constituent(s) are causing the ionic imbalance. Complexing, coprecipitation, or adsorption may be removing some anionic constituents.

Figures 9 through 17 in Appendix D show the changes in major ion constituents with discharge at gaging stations on Pitchfork Creek. The major ion constituents graphed are: sodium, calcium, magnesium, bicarbonate, sulfate, chloride, potassium and fluoride. Figures 9 through 11 in Appendix D illustrate the change in major ion constituents in the gaging station on Pitchfork Creek above Dunkle Creek ([illegible]). Bicarbonate and sulfate levels appear to vary little with changes in discharge. There is some evidence that they decrease in concentration during spring, or at least become more erratic, which may be due to a dilution effect of baseflow from runoff. Potassium levels increase during runoff, indicating superficial sources, while fluoride remains the same during all ranges of flow. Chloride levels fluctuate, but appear to be reacting to some factor other than runoff, i.e., baseflow dilution or concentration. Sodium is very steady during baseflow and is a good indicator of ground water discharge. Sodium is diluted during runoff and concentrated during the irrigation season. Calcium and magnesium levels are fairly steady, showing small dilutions during runoff, and increased concentration during the heavy irrigation period of July.

Figures 12 through 14 in Appendix D demonstrate changes in chemical parameters with change in flow at the gaging station on Pitchfork Creek below Ryan Gulch ([illegible]). Bicarbonate and sulfate levels show a small response to changes occurring between baseflow and the remainder of the water year. They are lowest during baseflow and gradually increase during warmer periods. This is probably a result of influence of temperature on solubility (differences between colder and warmer water). Chloride levels are also coincident with winter high flow events, but do not react to runoff. Potassium levels reflect similar anomalous flow events but react little during the rest of the year. Fluoride levels drop slightly in February but remain essentially stable. Sodium levels are coincident with the irrigation season, being more concentrated during the spring and summer. Calcium and magnesium react little to seasonal changes at station 200.

Figures 15 through 17 in Appendix D illustrate changes in chemical constituents with flow at the station on Piceance Creek near the White River (09306210). This is a water quality sampling station located just below Horse Draw. Sulfate and bicarbonate values are very similar to values for the station above Ryan Gulch but appear to be reacting less to individual flow events. Chloride values are different, however, indicating that chemical factors are causing change over very short distances. Potassium reacts significantly to only one of the high winter flow events, while fluoride values remain stable throughout the year. Calcium and magnesium levels are relatively stable although they begin to rise during irrigation periods. Sodium is stable during baseflow and rises steeply in May and June, also due to irrigation.

Suspended Sediment

Suspended sediment is predictably highest during spring runoff and during intense rainstorms. Frickel, Shown, and Patton (1975) have estimated that the annual sediment yield based on water year 1974 was 95 m^3/km^2 (0.2 ac-ft/mi^2) for the 1256 km^2 (485 sq mi) of drainage area above the Ryan Gulch gaging station.

Figures 18 and 19 in Appendix D show respectively the correspondence of suspended sediment concentration with flow for gaging stations on Piceance Creek above Hunter Creek (09306061) and below Ryan Gulch (09306200). Both graphs show an axial trend; however, the trend is initiated at higher discharge for the station below Ryan Gulch, which is expected due to its downstream location. Points are scattered at lower flows but show a definite axial trend when flow increases to about 4 cfs at the station above Hunter Creek and about 10 cfs at the station below Ryan Gulch. These trends are reflective of higher, more turbulent flow events which are caused by either rapid snowmelt (which releases and carries small particles), or by high intensity storms, which dislodge and carry small particles. These rapid increases of suspended sediment corresponding to discharge are typical of most semi-arid environments.

4.5.2 Water Use

The primary use of surface waters in this area is for irrigation. Wymore (1974) estimated that streamflow depletion due to irrigation along Piceance Creek amounts to 4.9 hm^3 (3,950 ac-ft) per year. Weeks et al.(1974) estimated the average annual yield of the Piceance Creek drainage and found it to be 23.7 hm^3 (19,260 ac-ft) prior to irrigation development. This value was developed by increasing the estimated streamflow depletion from irrigation by 20%, to account for evapotranspiration of irrigation diversions by non-beneficial vegetation.

Figures 15 through 17 in Appendix D illustrate changes in chemical constituents with flow at the station on Piceance Creek near the White River (09306210). This is a water quality sampling station located just below Horse Draw. Sulfate and bicarbonate values are very similar to values for the station above Ryan Gulch but appear to be reacting less to individual flow events. Chloride values are different, however, indicating that chemical factors are causing change over very short distances. Potassium reacts significantly to only one of the high winter flow events, while fluoride values remain stable throughout the year. Calcium and magnesium levels are relatively stable although they begin to rise during irrigation periods. Sodium is stable during baseflow and rises steeply in May and June, also due to irrigation.

Suspended Sediment

Suspended sediment is predictably highest during spring runoff and during intense rainstorms. Frickel, Shown, and Patton (1975) have estimated that the annual sediment yield based on water year 1974 was 95 m^3/km^2 (0.2 ac-ft/mi^2) for the 1256 km^2 (485 sq mi) of drainage area above the Ryan Gulch gaging station.

Figures 18 and 19 in Appendix D show respectively the correspondence of suspended sediment concentration with flow for gaging stations on Piceance Creek above Hunter Creek (09306061) and below Ryan Gulch (09306200). Both graphs show an axial trend; however, the trend is initiated at higher discharge for the station below Ryan Gulch, which is expected due to its downstream location. Points are scattered at lower flows but show a definite axial trend when flow increases to about 4 cfs at the station above Hunter Creek and about 10 cfs at the station below Ryan Gulch. These trends are reflective of higher, more turbulent flow events which are caused by either rapid snowmelt (which releases and carries small particles), or by high intensity storms, which dislodge and carry small particles. These rapid increases of suspended sediment corresponding to discharge are typical of most semi-arid environments.

4.5.2 Water Use

The primary use of surface waters in this area is for irrigation. Wymore (1974) estimated that streamflow depletion due to irrigation along Piceance Creek amounts to 4.9 hm^3 (3,990 ac-ft) per year. Weeks et al.(1974) estimated the average annual yield of the Piceance Creek drainage and found it to be 23.7 hm^3 (19,200 ac-ft) prior to irrigation development. This value was developed by increasing the estimated streamflow depletion from irrigation by 25%, to account for evapotranspiration of irrigation diversions by non-beneficial vegetation.

4.5.3 Flooding Potential

Flood hydrology of the drainages in the vicinity of the project site was investigated with techniques developed by McCain and Jarret (1976) for estimating peak flood discharge in ungaged watersheds in Colorado. Utilizing this technique, peak 100-year flood discharges were estimated for three locations, Piceance Creek at Horse Draw, Horse Draw at the project site, and an unnamed tributary to Horse Draw to a point adjacent to the holding pond. The discharges were 4250, 260 and 68 cfs, respectively.

4.5.4 Erosion Potential

The surface soils in this area are well drained and calcerous (Eutroboralf Association, see Section 4.4.6) and are highly vulnerable to disturbance and erosion. Basically, even minor disruption of the plant cover (see Section 4.1.1) via wind and surface runoff can cause erosion. However, the USBM potential area of disturbance is only about 9.0 ha (22.2 acres), and as such will not contribute significantly to erosion of the entire area.

4.6 Ground Water Hydrology

4.6.1 Aquifer Description

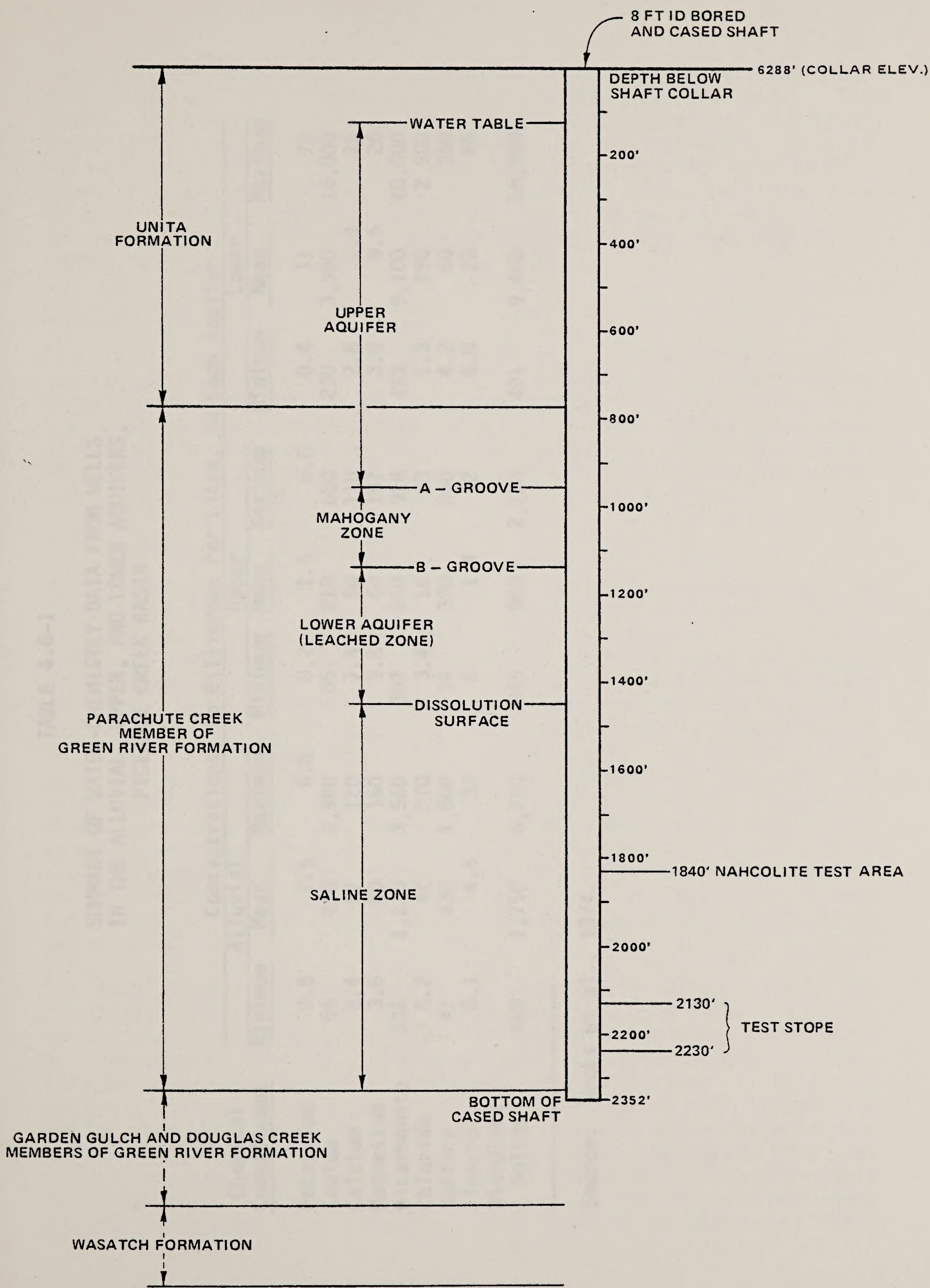
The principal aquifers in the Piceance Creek basin are in the Uinta and Green River formations, which consist of two aquifers separated by a confining layer as shown in Figure 4.6-1 (Weeks et al., 1974). Depending on thickness and composition, the alluvium is an important aquifer in some locations.

Alluvial Aquifer

The alluvial aquifers are limited to the valley bottoms along the creeks. These aquifers are generally less than 0.8 km (0.5 mile) in width with thicknesses of up to 42.7 m (140 ft) and a saturated thickness of up to 30 m (100 ft). The alluvium is principally composed of sand, gravel, and clay derived from the sandstone and marlstone of the Uinta formation. Water in the alluvium occurs under both water table and confined conditions, depending on the occurrence of claybeds (Weeks et al., 1974).

Upper Aquifer

The upper aquifer consists of fractured, lean oil shale (marlstone) of the Parachute Creek member above the Mahogany zone, and the fractured marlstone, siltstone, and sandstone of the Uinta formation. The permeability of the aquifer is mainly due to secondary, or fracture porosity. The siltstone and sandstone beds of the Uinta formation have been cemented by precipitates from percolating water, resulting in very



GENERALIZED GEOLOGIC COLUMN OF PROJECT AREA

FIGURE 4.6-1

TABLE 4.6-1

SUMMARY OF WATER-CHEMISTRY DATA FROM WELLS
IN THE ALLUVIAL, UPPER, AND LOWER AQUIFERS,
PICEANCE CREEK BASIN

Chemical	Concentrations, in Milligrams Per Litre, in Each Aquifer								
	Alluvial			Upper			Lower		
Constituent	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Potassium	0.8	2.5	6.8	0.2	1.5	6.0	0.4	11	78
Sodium	66	490	2,900	55	210	650	230	3,980	16,000
Calcium	2.4	57	120	7.4	50	110	2.8	7.4	15
Magnesium	3.6	80	160	9.8	60	187	3.0	9.5	26
Bicarbonate	336	1,220	3,560	307	550	918	493	9,100	40,000
Chloride	5.2	42	270	3.4	16	63	1.3	690	2,900
Sulfate	41	430	1,500	34	320	850	4.2	80	350
Fluoride	0.1	4.6	33	0	1.4	12	5.0	28	66
Dissolved Solids	469	1,750	6,720	345	960	2,180	491	9,400	38,900

Source: Weeks et al., 1974.

The upper aquifer is complicated by a series of marlstone and sandstone beds with varying permeabilities and degrees of confinement. The aquifer is generally confined by low-permeability sandstones but may be unconfined in many locations, particularly in outcrop areas. Many of the marlstone beds in the Uinta formation contain perched water bearing zones that are not part of the upper aquifer. These marlstone beds occur in the ridges between stream valleys. The perched water bodies can usually be identified by the occurrence of springs above the valley bottom in outcrop areas (Weeks et al., 1974).

Lower Aquifer

The lower aquifer consists of the fractured oil shale and marlstone of the Parachute Creek member underlying the Mahogany zone. The secondary porosity and permeability of the lower aquifer have been enhanced by the solution of minerals, principally nahcolite, a sodium bicarbonate mineral. The lower aquifer is frequently referred to as the leached zone because of the leaching of soluble minerals by percolating water, which results in low resistivity on electric logs.

4.6.2 Description of Confining Strata

The upper and lower aquifers are separated by the Mahogany zone, an interval of rich oil shale 30 to 60 m (100 to 200 ft) thick. Within the Mahogany zone an interval ranging from 0.9 to 3 m (3 to 10 ft), known as the Mahogany bed, is probably the principal confining layer. Correlations of fracture density and kerogen content indicate that the oil shale, which is rich in kerogen, is more resistant to fracturing than the lean shale. Consequently, the Mahogany zone is less permeable than the rocks immediately above or below it. The Mahogany zone persists throughout the basin and effectively separates the upper and lower aquifers both chemically and hydraulically. The small number of fractures within the zone, however, do permit some vertical exchange of water between the aquifers, particularly in the recharge and discharge areas. Local head differences between the upper and lower aquifers rarely exceed 30.5 m (100 ft) in the basin. If the Mahogany zone were completely impermeable, large head differences would have been measured (Weeks et al., 1974).

The lower aquifer is underlain by an impermeable saline zone of the Parachute Creek member. At the project area this zone is over 900 feet in thickness and contains the shale oil and saline minerals to be mined by this proposed project. The mine stope is located within the lower portion of the saline zone. There are no open fractures in this zone of rock, and all previously existing fractures have been filled with saline minerals (nahcolite and dawsonite), probably deposited by moving ground water during a previous geologic period. Therefore, this zone is very dry and appears to be structurally competent. The saline zone is underlain by several hundred feet of mainly sandstone and marlstone of the Garden Gulch and Douglas Creek members of the Green River

formation. Both units are relatively impermeable and are not a significant source of ground water in the Piceance Creek Basin.

4.6.3 Ground Water Movement

Recharge

Recharge to the aquifer system occurs principally from snowmelt during the spring. During the summer months, rainfall is lost as direct runoff or goes to meet the soil moisture deficiency, which is subsequently evapotranspired. Probably little, if any, rainfall infiltrates and percolates to the saturated zone of the ground water system except in the alluvium. On the other hand, several inches of water may accumulate in the winter snowpack. In the spring this water in storage is released slowly, allowing ample opportunity for the melt to infiltrate the soil, increase the soil-moisture content to field capacity, and percolate to the saturated zone. The process is more effective at the higher altitudes, where water is in storage as snow. Recharge to the aquifer system is most effective in the areas of the basin which are above an elevation of 2.1 km (7,000 ft) where about 65 percent of the total volume of November to March precipitation occurs.

In the recharge area, water from the upper aquifer moves downward through the Mahogany zone to recharge the lower aquifer. Generally, ground water in both the upper and lower aquifers flows from the recharge areas at the basin margins toward the north-central part of the basin (Weeks et al., 1974).

Discharge

The project area is in a portion of the ground water discharge region, where water moves upward from the lower aquifer through the Mahogany zone to the upper aquifer. Water is discharged from the upper aquifer to the alluvium through the valley floors and by springs along the valley walls. The ground water flows through the alluvium to the streams and is lost from the basin by evapotranspiration and discharge to Piceance Creek and Yellow Creek. No significant amount of ground water discharge from the Green River formation reaches the White River except through Piceance and Yellow Creeks. The Wasatch formation crops out along the White River and prevents ground water discharge from the Piceance Creek Basin to the White River (Weeks et al., 1974).

Potentiometric Surface

The general direction of ground water flow in the Piceance Creek Basin can be determined from potentiometric maps based on water levels. The general direction of ground water flow in both aquifers is to the north. The elevation of water levels within the upper and lower aquifers ranges from about 2.2 to 1.8 km (7,200 to 5,900 ft).

The approximate depth to water in the upper and lower aquifers in the project area is 45.7 m (150 ft) (elevation of 1,900 m [6,140 ft]). The upper and lower aquifers are separated by about 61 m (200 ft) of the Mahogany zone. Slow vertical movement through the Mahogany zone has resulted in similar water levels in the upper and lower aquifers throughout the basin.

4.6.4 Results of Geohydrologic Testing and Analysis

Alluvial Aquifer

The transmissivity of the alluvial aquifers is highly variable, depending on the saturated thickness and the occurrence of clay- or silt-size material. Transmissivity ranges from 800 to 6,100 m^2/day (2,700 to 20,000 ft^2/day) and the storage coefficient averages 0.20. However, because of the limited areal extent of the aquifer, geologic boundaries greatly influence the drawdown in discharge wells. Aquifer test data clearly show the effects of increased drawdown resulting from the boundaries of the alluvium. Consequently, relatively large pumping rates can be obtained from wells in the alluvium, but the rate can be maintained only for brief periods of time because of the limited areal extent of the aquifers (Weeks et al., 1974).

Upper Aquifer

A regional study of the Piceance basin by Weeks et al., (1974) reported that transmissivity of the upper aquifer ranges from 2.4 to 304.9 m^2/day (8 to 1,000 ft^2/day). Most of the data were collected from oil-shale core holes in the vicinity of the protoytpe oil shale lease tracts and consequently, the data were not well distributed. The data are highly variable, which is to be expected in a non-homogeneous fractured-rock aquifer. The transmissivity tends to increase from west to east because the aquifer is thin on the west side of the basin and thickens eastward. In general, aquifer tests have a small area of influence and do not necessarily result in transmissivity values typical of the region.

The transmissivity from aquifer tests (holes 01A and 02A) located along Horse Draw within the USBM tract indicate substantially greater values. The probable reason is the close proximity to a fault zone. Results of aquifer tests indicate that the upper aquifer at the project site has a transmissivity of 792.7 m^2/day (2,600 ft^2/day). A storage coefficient of 2.5×10^{-3} was determined from analysis of hole 01A (Dale and Weeks, 1978).

Golder and Associates (1977) reported transmissivities of 108.5 and 497 m^2/day (356 and 1,630 ft^2/day) for tests conducted on Pilot Hole "X" at the USBM tract. Transmissivities for several tests on Shell well 41-9 located about three miles north of the USBM tract, ranged from 1.2 to 7.6 m^2/day (4 to 25 ft^2/day), and for Shell well

The approximate depth to water in the upper and lower aquifers in the project area is 45.7 m (150 ft) (elevation of 1,990 m [6,530 ft]). The upper and lower aquifers are separated by about 61 m (200 ft) of the Mahogany zone. Slow vertical movement through the Mahogany zone has resulted in similar water levels in the upper and lower aquifers throughout the basin.

4.6.4 Results of Geohydrologic Testing and Analysis

Alluvial Aquifer

The transmissivity of the alluvial aquifers is highly variable, depending on the saturated thickness and the occurrence of clay- or silt-size material. Transmissivity ranges from 250 to 9,300 m²/day (2,700 to 100,000 ft²/day) and the storage coefficient averages 0.20. However, because of the limited areal extent of the aquifer, geologic boundaries greatly influence the drawdown in discharging wells. Aquifer test data clearly show the effects of increased drawdown resulting from the boundaries of the alluvium. Consequently, relatively large pumping rates can be obtained from wells in the alluvium, but the rate can be maintained only for brief periods of time because of the limited areal extent of the aquifers (Weeks et al., 1974).

Upper Aquifer

A regional study of the Piceance basin by Weeks et al., (1974) reported that transmissivity of the upper aquifer ranges from 0.7 to 104.0 m²/day (8 to 1,000 ft²/day). Most of the data were collected from oil-shale core holes in the vicinity of the prototype oil shale lease tracts and, consequently, the data were not well distributed. The data are highly variable, which is to be expected in a non-homogeneous fractured-rock aquifer. The transmissivity tends to increase from west to east because the aquifer is thin on the west side of the basin and thickens eastward. In general, aquifer tests have a small area of influence and do not necessarily result in transmissivity values typical of the region.

The transmissivity from aquifer tests (holes [illegible] and [illegible]) located along Horse Draw within the [illegible] tract indicate substantially greater values. The probable reason is the close proximity to a fault zone. Results of aquifer tests indicate that the upper aquifer at the project site has a transmissivity of 158.1 m²/day (1,[illegible] ft²/day). A storage coefficient of 2.5×10^{-5} was determined from analyses of hole [illegible] (Dale and Weeks, 1978).

Golder and Associates (1977) reported transmissivities of 125.4 and 497 m²/day (1350 and 1,350 ft²/day) for tests conducted in Pilot Hole "X" at the USBM tract. Transmissivities for several tests on Shell well 41-X located about three miles north of the USBM tract, ranged from 1.2 to 7.8 m²/day (4 to 84 ft²/day), and for Shell well

23X-2, located about one mile southwest of the USBM tract, from 1.2 to 73.2 m^2/day (4 to 240 ft^2/day) (Ficke et al., 1974). The approximate locations of geohydrologic test holes 01A and 02A are shown on Figure 4.6-2.

Lower Aquifer

Regional transmissivity values of the lower aquifer range from 2.4 to 591.5 m^2/day (8 to 1,940 ft^2/day) (Weeks, et al., 1974). As discussed previously, aquifer test data represent a small area of influence, and the resultant transmissivity may not be typical of the region. Transmissivity values of the lower aquifer are primarily dependent on the degree of dissolution of saline minerals, amount of fracturing, and thickness. Results of aquifer tests (hole 02A) indicate that the lower aquifer at the USBM site has a transmissivity of 64.0 m^2/day (210 ft^2/day).

Pump tests were conducted in the lower aquifer within and near the USBM tract at Shell wells 41-9 and 23X-2. Well 41-9 had a transmissivity of 134.1 m^2/day (440 ft^2/day); well 23X-2 had transmissivity values ranging from 10.6 to 246.3 m^2/day (35 to 808 ft^2/day) (Ficke et al., 1974).

Saline Zone

The saline zone extends from depths of about 442 to 732 m (1,450 to 2,400 ft) at the USBM tract. A total of 13 successful drill stem tests were conducted on the zone from the depths of 549 to 726 m (1,800 to 2,382 ft) in USBM Corehole #1 near the location of the mine shaft (Multi Minerals, 1980). For this method of testing, a testing tool attached to the drill pipe is lowered into the hole and placed opposite the formation to be tested. Packers are set to shut off the weight of the drilling mud, and the tool is opened to permit the flow of any formation fluid into the drill pipe, where the flow can be measured. No water flowed from the formation intervals tested. These tests indicate that the saline zone is dry and virtually impermeable.

4.6.5 Ground Water Uses

The records of the Colorado State Engineer's Office disclose two water wells which have been drilled within a two mile radius of the USBM site:

1. T1S, R97W, Section 28: NW1/4 SW1/4. Depth is 98 feet.
2. T1S, R97W, Section 32: SE1/4 NE1/4. Depth is 100 feet.

According to these records, the deepest formation penetrated by each well is the Uinta formation which consists of sandstone and siltstone. The Engineer's Office does not have information concerning current

23X-2, located about one mile southwest of the USSM tract, from 2.2 to 13.2 m^2/day (4 to 250 ft^2/day) (Ficke et al., 1974). The approximate locations of geohydrologic test holes 23X and 40A are shown on Figure 4.6-2.

Lower Aquifer

Regional transmissivity values of the lower aquifer range from 2.4 to 591.5 m^2/day (8 to 1,940 ft^2/day) (Weeks, et al., 1974). As discussed previously, aquifer test data represent a small area of influence, and the resultant transmissivity may not be typical of the region. Transmissivity values of the lower aquifer are primarily dependent on the degree of dissolution of saline minerals, amount of fracturing, and thickness. Results of aquifer tests (hole 02A) indicate that the lower aquifer at the USSM site has a transmissivity of 54.0 m^2/day (210 ft^2/day).

Pump tests were conducted in the lower aquifer within and near the USSM tract at Shell wells 41-9 and 23X-2. Well 41-9 had a transmissivity of 134.1 m^2/day (440 ft^2/day); well 23X-2 had transmissivity values ranging from 10.6 to 246.3 m^2/day (35 to 808 ft^2/day) (Ficke et al., 1974).

Saline Zone

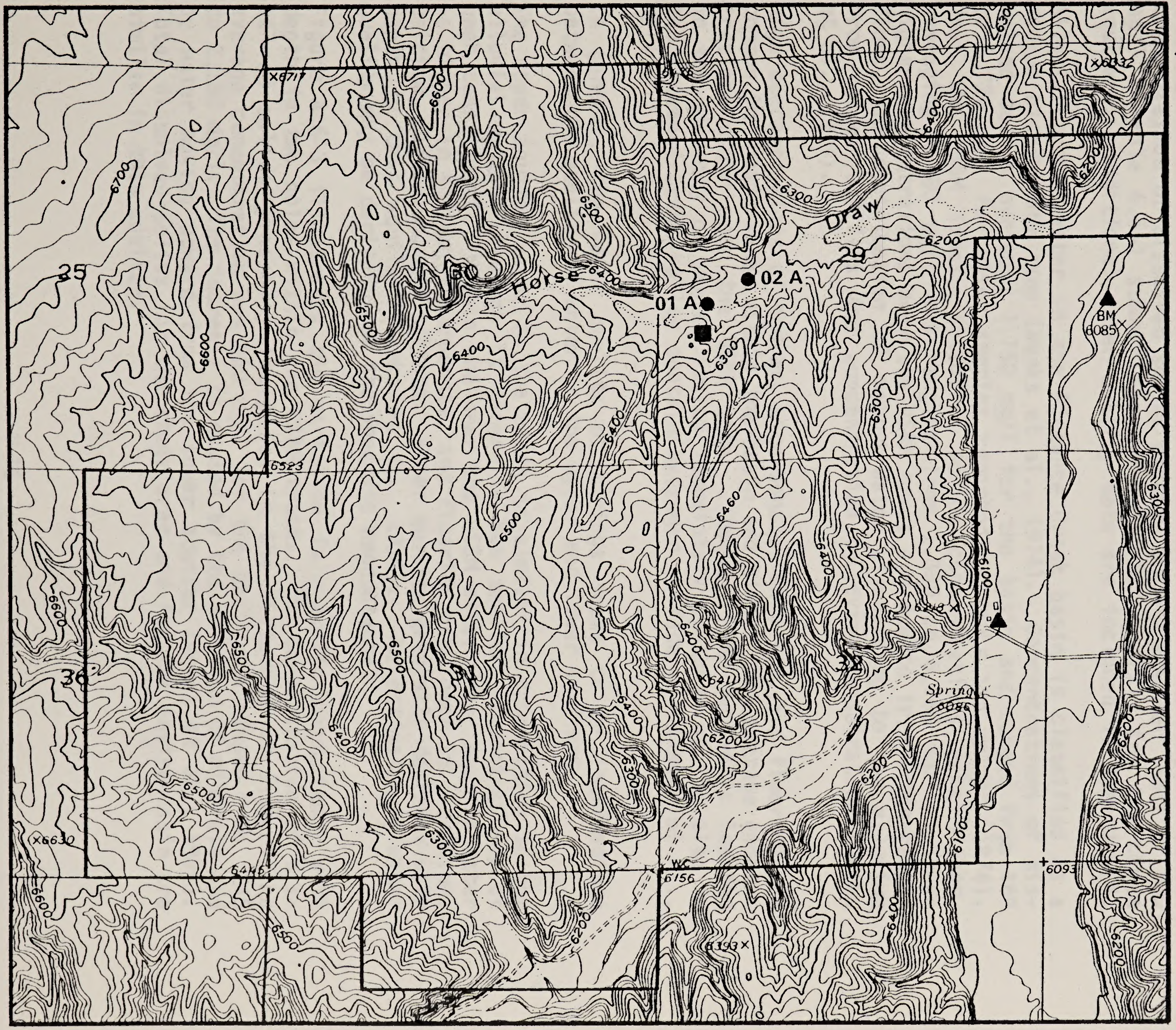
The saline zone extends from depths of about 442 to 732 m (1,450 to 2,400 ft) at the USSM tract. A total of 13 successful drill stem tests were conducted on the zone from the depths of 445 to 726 m (1,460 to 2,382 ft) in USSM Corehole #1 near the location of the mine shaft (Multi Minerals, 1980). For this method of testing, a testing tool attached to the drill pipe is lowered into the hole and placed opposite the formation to be tested. Packers are set to shut off the weight of the drilling mud, and the tool is opened to permit the flow of any formation fluid into the drill pipe, where the flow can be measured. No water flowed from the formation intervals tested. These tests indicate that the saline zone is dry and virtually impermeable.

4.6.5 Ground Water Uses

The records of the Colorado State Engineer's Office disclose two water wells which have been drilled within a two mile radius of the USSM site:

1. T1S, R97W, Section 28: NW1/4 SW1/4. Depth is 48 feet.
2. T1S, R97W, Section 32: SE1/4 NE1/4. Depth is 100 feet.

According to these records, the aquifer formation penetrated by each well is the Uinta formation which consists of sandstone and siltstone. The Engineer's Office does not have information concerning current



LEGEND

STUDY AREA BOUNDARY

● GEOHYDROLOGIC TEST HOLES

▲ KNOWN WATER WELLS WITHIN 2 MILES OF THE MINE

■ PILOT HOLE "X" AND RESEARCH FACILITY

NOTE: 1. ALL LOCATIONS ARE APPROXIMATE

2. ONLY WATER WELLS ON RECORD WITH COLORADO STATE ENGINEERS OFFICE ARE SHOWN

N

LOCATION OF GEOHYDROLOGIC TEST HOLES AND WATER WELLS

FIGURE 4.6-2

operation or abandonment of the wells. The approximate locations of these wells are shown on Figure 4.6-2.

Ground Water Quality

Ground water quality in the Piceance Creek Basin varies both within and among the aquifers. EPA and State of Colorado water quality standards are generally not met by water from the alluvial, upper, and lower aquifers. In all but 3 of 75 reported analyses for Piceance Creek Basin ground water (Ficke et al, 1974 and Weeks and Welder, 1974), the concentration of dissolved solids exceeds the recommended limit of 500 mg/l. Table 4.6-1 summarizes ground water quality for the three aquifers. Additional water quality data are included in Appendix E.

Alluvial ground water in the Piceance Creek basin is classified as a sodium bicarbonate type (Weeks et al., 1974). Concentrations of dissolved solids averaged 1,750 mg/l for the basin and ranged from 469 to 6,720 mg/l for water samples reported by Weeks and Welder (1974). Near the USBM Tract, dissolved solids concentrations were higher, averaging 4,680 mg/l and ranging from 1,830 to 6,760 mg/l. These higher concentrations near the USBM tract are due to irrigation-return flows, the contribution of ground water discharging to the alluvium from deeper aquifers and concentration by evapotranspiration (Weeks et al., 1974).

High concentrations of sodium, bicarbonate, chloride, and fluoride are common in ground water within the basin and higher than average concentrations occur near the USBM site. Samples from two wells located in the vicinity of mapped faults immediately upstream of the site in the Piceance Creek valley contain hydrogen sulfide gas (Weeks et al., 1974).

In general, the water quality of springs seems to be intermediate between the quality of water in the upper and lower aquifers.

The upper aquifer water in the basin is similar in composition to the alluvial water, although it generally has smaller concentrations of each constituent. Within and near the USBM site, upper aquifer water is higher in sodium, bicarbonate, and fluoride but lower in potassium, calcium, magnesium, and sulfate. Water quality generally degrades with depth in this aquifer (Weeks et al., 1974). An estimate of water quality may be derived from the specific conductance.

Figure 4.6-3 illustrates the variation in specific conductance with depth in two holes within the USBM tract. The concentration of dissolved solids generally increases in the direction of flow. The average concentration was 960 mg/l for the basin and ranged from 345 to 2,180 mg/l. The increase is caused by the solution of minerals and by water moving upward from the lower aquifer (Weeks et al., 1974). Total dissolved solids for the study area and for the entire basin are similar in this aquifer.

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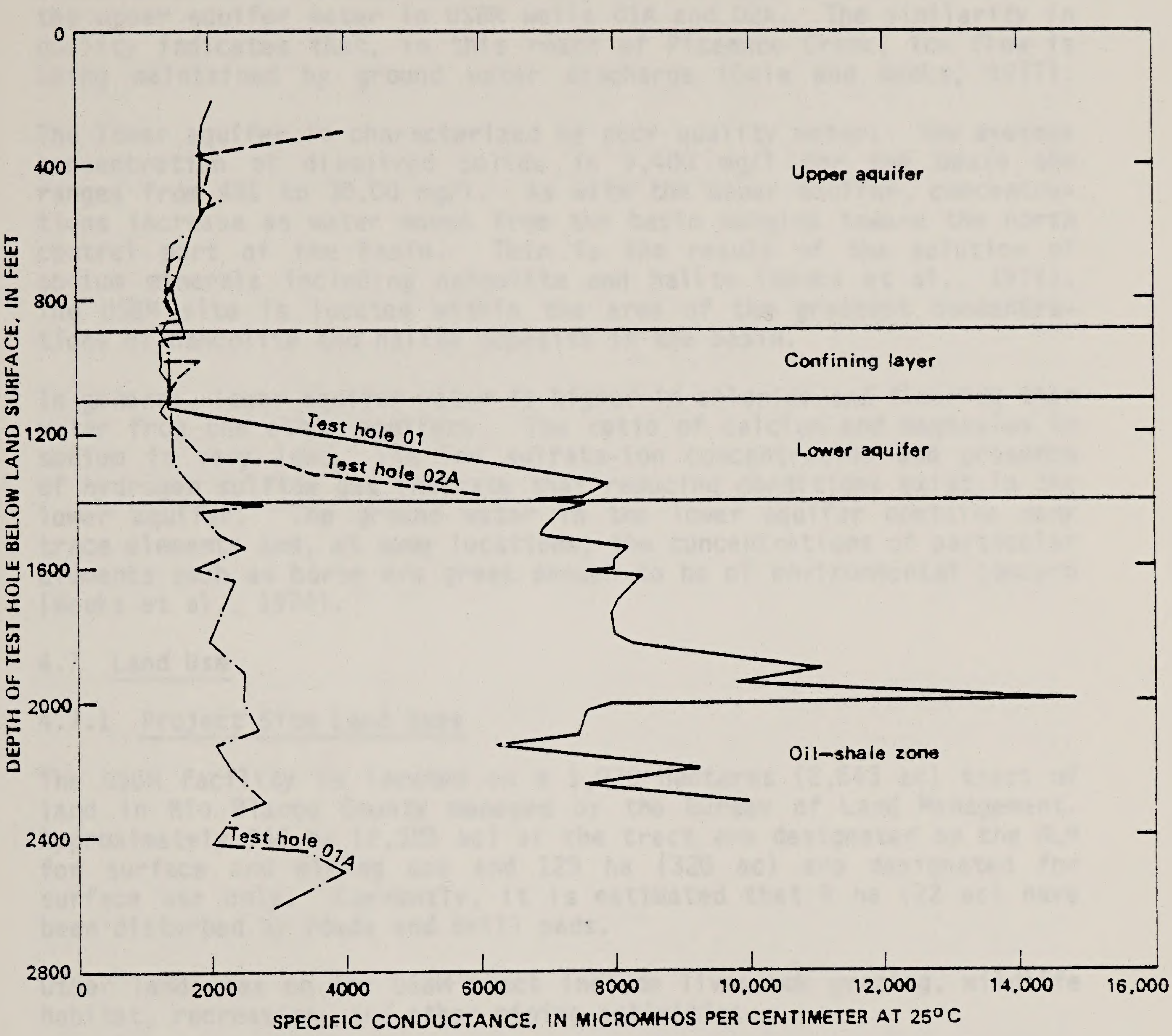

NOTE: SPECIFIC CONDUCTANCE OF GROUND WATER DISCHARGED DURING DRILLING

VARIATION OF SPECIFIC CONDUCTANCE WITH DEPTH

FIGURE 4.6-3

SOURCE: Dale and Weeks, 1974

Near the confluence of Horse Draw and Piceance Creek, dissolved solids concentrations of surface water during low flow are similar to those of the upper aquifer water in USBM wells 01A and 02A. The similarity in quality indicates that, in this reach of Piceance Creek, low flow is being maintained by ground water discharge (Dale and Weeks, 1977).

The lower aquifer is characterized by poor quality water. The average concentration of dissolved solids is 9,400 mg/l for the basin and ranges from 491 to 38,00 mg/l. As with the upper aquifer, concentrations increase as water moves from the basin margins toward the north central part of the basin. This is the result of the solution of sodium minerals including nahcolite and halite (Weeks et al., 1974). The USBM site is located within the area of the greatest concentrations of nahcolite and halite deposits in the basin.

In general, lower aquifer water is higher in chloride and fluoride than water from the other aquifers. The ratio of calcium and magnesium to sodium is very low. The low sulfate-ion concentration and presence of hydrogen sulfide gas indicate that reducing conditions exist in the lower aquifer. The ground water in the lower aquifer contains many trace elements and, at some locations, the concentrations of particular elements such as boron are great enough to be of environmental concern (Weeks et al., 1974).

4.7 Land Use

4.7.1 Project Site Land Uses

The USBM facility is located on a 1,070 hectares (2,643 ac) tract of land in Rio Blanco County managed by the Bureau of Land Management. Approximately 940 ha (2,323 ac) of the tract are designated by the BLM for surface and mining use and 129 ha (320 ac) are designated for surface use only. Currently, it is estimated that 9 ha (22 ac) have been disturbed by roads and drill pads.

Other land uses on the USBM tract include livestock grazing, wildlife habitat, recreation, and other mining activities.

Livestock Grazing

The USBM tract is located in the Square S grazing allotment which is divided into 6 pastures managed under a BLM approved Allotment Management Plan (Piceance Wildlife, 1977). The research facility site is located within Pasture F. Approximately 1,000 head of cattle are scheduled for grazing in Pasture F during the May to December period of each year (Fusselman, pers. comm., 1977). Approximately 20 animal units of forage are produced on the 105 ha (260 ac) mining area where surface disturbance was originally expected, with most forage production on the chained area in the southern portion of the 105 ha (260 ac) (USBM, 1976).

Near the confluence of Horse Draw and Piceance Creek, dissolved solids concentrations of surface water during low flow are similar to those of the upper aquifer water in USBM wells 02A and 02B. The similarity in quality indicates that, in this reach of Piceance Creek, low flow is being maintained by ground water discharge (Dale and Weeks, 1977).

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4.7.1 Project Site Land Uses

The USBM facility is located on a 1,070 hectares (2,643 ac) tract of land in Rio Blanco County managed by the Bureau of Land Management. Approximately 940 ha (2,323 ac) of the tract are designated by the BLM for surface and mining use and 129 ha (320 ac) are designated for surface use only. Currently, it is estimated that 9 ha (22 ac) have been disturbed by roads and drill pads.

Other land uses on the USBM tract include livestock grazing, wildlife habitat, recreation, and other mining activities.

Livestock Grazing

The USBM tract is located in the Square S grazing allotment which is divided into 6 pastures managed under a BLM approved Allotment Management Plan (Piceance Wildlife, 1977). The research facility site is located within Pasture F. Approximately 1,990 head of cattle are scheduled for grazing in Pasture F during the May to December period of each year (Fusselman, pers. comm., 1977). Approximately 89 animal units of forage are produced on the 105 ha (260 ac) mining area where surface disturbance was originally expected, with most forage production on the chained area in the southern portion of the 105 ha (260 ac) (USBM, 1976).

Wildlife Habitat

The USBM tract is also within an identified deer winter range and a high concentration area for deer (USBM, 1976). Deer are generally present from about October to May, with the highest concentrations on the edges of the chained areas in the upper part of Horse Draw (USBM, 1976). Other wildlife species are found on and adjacent to the mining area and are discussed in detail in the section on Wildlife, 4.1.2.

Recreation

Based on available information it can be concluded that recreation opportunities include big and small game hunting, rockhounding, and wildlife viewing (USBM, 1976; Big Game Harvest, 1976; Small Game Harvest, 1975). The USBM tract is included in Big Game Management Unit (BGMU) 22, one of the most productive BGMU's for mule deer in the state. BGMU 22, most of which lies within the county, received the second greatest amount of hunting pressure for mule deer in the state with 15,974 recreation days (Big Game Harvest, 1976).

The USBM tract also lies within Small Game Management Unit (SGMU) 22. The most frequently hunted small game species in SGMU is cottontail rabbit.

Recreational opportunities at the project site include rockhounding, due to interesting rock outcroppings on the site, and wildlife viewing including mule deer, bald and golden eagles, other raptors and other small birds and mammals (USBM, 1976).

Mining

Mineral and energy resources on the USBM tract include oil shale, oil and gas, and sodium minerals. The USBM tract overlaps oil and gas leases, portions of sodium lease application areas and a tract nominated by industry for in-situ development of oil shale (Appendix F).

The USBM Tract is currently zoned A-1 agriculture but has been issued a conditional use permit by the county (Rehborg, pers. comm., 1977). Current development on the USBM site includes a 2.4 m (8 foot) diameter shaft, two drill pads, a holding pond just to the west of the shaft, and an improved road from the Piceance Creek Road up Horse Draw to the site. The amount of land area currently developed is approximately 4.5 ha (11 acres). No other significant development exists on the USBM tract.

4.7.2 Regional Land Use

The project area is located in Rio Blanco County. Major land uses include agriculture, mineral and energy resource development, recreation, residential, and commercial and industrial.

Agriculture

Most of the county is zoned for agriculture, with livestock grazing being the major agricultural use. Many livestock operators rely on BLM or USFS grazing leases in conjunction with their own land for grazing forage. In addition to livestock grazing, several crops are produced, principally hay and wheat.

Mining

Mineral and energy resources are abundant in the county. These resources include oil, gas, oil shale, coal, and uranium (Energy Resource Map, CGS, 1976; Surface-Mineral Maps, BLM). In 1976 there were approximately 632 producing oil and gas wells in the county (Oil and Gas Statistics, 1976). Approximately 480 billion barrels of oil are located in the oil shale beds of the Piceance Creek Basin of Garfield, Mesa, and Rio Blanco counties (Colorado Deptartment of Local Affairs, 1975). In addition, most of the county is located in a coal bearing region, with existing federal coal leases located northeast of Meeker and north of Rangely (Energy Resources Map, CGS, 1976; NW Coal, 1977). Selected mineral and energy resources and energy developments are displayed in Appendix F.

Recreation

Recreation activities throughout the county include hunting, fishing, horseback riding, driving for fun, camping, and hiking (RIM, 1976). Recent data indicate that the supply of most recreation opportunities outweighs demand for those activities. Demand and supply data are provided in Appendix F.

Residential

Residential uses of land are almost entirely located within or adjacent to existing communities. Approximately 501 hectares (1,238 ac) of the county are zoned single family residential (Tri-County, 1976), including a large area on the southeast border of Rangely and six areas around the Town of Meeker (County Zoning Maps, 1977).

Industrial and Commercial

Industrial uses are confined to primarily those areas in the county zoned for such uses (Rehborg, pers. comm., 1977). Industrial zones comprise approximately 402 ha (994 ac) (Tri-County, 1976). Commercial uses are confined to areas zoned "highway business." Numerous "highway business" zones are scattered along major transportation arteries (County Zoning Maps, 1977; Rehborg, pers. comm., 1977).

The major communities in the study area are Rangely and Meeker in Rio Blanco County, and Rifle, which is located in northern Garfield

County. These communities are currently being affected by energy development activities in Rio Blanco and surrounding counties.

4.7.3 Land Use Plans

The proposed Multi Mineral Corporation (MMC) research program for an integrated in-situ oil shale pyrolysis process would utilize the USBM research facilities at Horse Draw. The facilities are located within a USBM tract which is included within the White River Management Framework Plan (MFP) administered by the U.S. Bureau of Land Management (BLM). The MFP prescribes management direction, and establishes objectives and constraints for each resource and support activity within the planning units of the MFP.

Special Land Use Permits C-22671, C-22672, and S-CO-101-76-7 have been issued to the USBM by the BLM for initial project preparation and for an access road to the project site. The BLM found no conflicts between the proposed project and BLM land use for the area, as designated in the MFP.

In July of 1977 the BLM entered into a "Memorandum of Understanding" with the Rio Blanco County Board of County Commissioners. The purpose of this agreement is to coordinate land use planning and decision making between the BLM and the County. The agreement contains a provision that BLM will insert in all licenses, permits, leases, and other such documents granting permission to occupy or use public lands a stipulation requiring all such licensees, permitees, and leasees to exercise the rights granted thereby in conformance with various Rio Blanco County Ordinances.

Rio Blanco County has one zoning ordinance for the entire county. The USBM presently has a Conditional Use Permit (CUP) issued by the County to conduct the proposed research project, because the site is presently zoned for agricultural use.

In order to assist in planning for large-scale energy projects, Rio Blanco county has adopted an impact regulation. This is imposed upon projects with an employment figure exceeding 1.25 percent of the county's population and requires an impact analysis dealing primarily with socioeconomic factors (Paine, pers. comm., 1980). Since Rio Blanco County's estimated population is 5,800, the MMC Research Program would have to employ over 87 persons for this regulation to apply. Current plans indicate that no mre than 50 persons would be employed at the research facility at any one time.

4.8 Socioeconomics

Rio Blanco County, its major communities (i.e., Meeker and Rangely), and Rifle in Garfield County comprise the socioeconomic study area. This report will concentrate mainly on Meeker and Rifle. These two

towns are most accessible and most likely where future Multi Mineral employees will reside.

Existing socioeconomic conditions in the study area are presented in six parts. The factors covered include population, housing, community services, utilities, economics and community attitudes. Specific characteristics of Rio Blanco County, Meeker, and Rifle are addressed. Special emphasis is placed on the town of Meeker because of its proximity to the project site and its ability to accommodate the small number of project-associated population. Rangely is fairly well removed from the project site, therefore little or no impact is projected for the town. Some background information will be given because of its significance in Rio Blanco County. Rangely and Meeker comprise 73% of the total population in the county. Rangely comprises 37%, with a population in 1977 of 1,871 although recent estimates are of 2,000 people. There has been a 38% increase in housing units since 1977, which indicates a rapid growth in the community. The school facilities are presently underutilized (Paine, pers. comm., 1980).

4.8.1 Population

The U.S. Department of Commerce conducted a special census in northwest Colorado, including Rio Blanco County, in March 1977 to determine the extent of population growth since 1970. Accordingly, during that period, population increased from 4,842 to 5,100; an increase of 5%. The County Development Department estimates the population to be approximately 5,800 presently, a 14% increase in three years (Paine, pers. comm., 1980). General 1970 and 1977 population characteristics in Rio Blanco County are summarized in Table 4.8-1. The largest population increase occurred in the 20 to 35 age groups. This increase reflects better employment opportunities for the working age group, and reverses the declining population trend that occurred between 1960 and 1970 (6%). Inhabitants of the study area are predominantly white (99.4%), and the distribution between males and females is fairly even. The county is predominantly rural, with the only urban centers being Meeker and Rangely.

Meeker

Between 1960 and 1970, population in Meeker declined 4 percent, from 1,655 to 1,597. This decline was attributed primarily to a lack of employment opportunities for the working-age population. The median age of the Meeker population is 32.0 years, compared to the state average of 26.2 years. Between 1970 and 1977, however, population increased 16 percent, to 1,848 (Special Census, 1977). Recent observations have indicated that Meeker's population has increased to well over 2,300. Precise population figures are not available.

TABLE 4.8-1

SUMMARY OF GENERAL POPULATION CHARACTERISTICS
RIO BLANCO COUNTY FOR 1970 & 1977

	1970	1977
Population		
All Persons		
Number	4,842	5,100
Percent Change 1960-1970	-6.0	5.3
Percent Negro and Other Races	1.1	0.6
Percent Under 18 Years	35.3	N/A
Percent 18 to 64 Years	56.5	N/A
Percent 65 Years and Over	8.2	N/A
Fertility Ratio[1]	345	N/A
Persons 14 Years and Over		
Percent Married - Male	64.4	N/A
Percent Married - Female	67.8	N/A
Persons 18 Years and over		
Percent Male	51.4	N/A
Households		
Number	1,474	1,731
Percent Change 1960-1970	-4.8	11.8
Persons Per Household	3.22	N/A
Population in Group Quarters		
Number	102	N/A
Percent of Total	2.1	N/A

[1] Children under 5 years per 1,000 women 15 to 49 years.

Source: U.S. Bureau of Census, 1971. U.S. Census of Population, 1970. General Population Characteristics, Colorado.

U.S. Bureau of Census, 1977, Special Census - Official Population Count for Rio Blanco County, Colorado.

Rifle

On January 1, 1980, Rifle's population was 3,800, a 4 percent increase from the 1970 census, according to Colorado West Area Council of Governments. The median age is 34.1 compared to the state average of 26.2 (Special Census, 1977).

Population projections for the county and respective cities can be found in Table 4.8-2.

4.8.2 Housing

Meeker

There is little or no surplus housing in Meeker. In September 1974, there were an estimated 739 dwelling units--580 single-family units, 60 multi-family units, 29 mobile homes, and 70 unspecified vacant units. In 1976, the number of mobile home units had increased to approximately 50, and in a Special Census conducted in March 1977 there were 685 occupied dwelling units and 71 vacant (unspecified) units. As of March 1979, there was a total of 899 housing units, which indicates a 31% increase in total housing stock in two years (Seagull, pers. comm., 1980).

In addition to the existing units there are 320 units in the final stages of construction, another 104 units with an expected completion date of June 1, 1981, and 5,000 units in the planning stages (Edwards, pers. comm., 1980).

Rifle

In the March 1977 Special Census, Rifle had a total of 862 occupied dwelling units. As of March 1979, this figure had increased 50% to 1,289 units (Seagull, pers. comm., 1980).

There are no current published figures on vacancy in the study area but there is a reported vacancy rate of less than 2 percemt throughout Rio Blanco County as well as in Rifle.

The large increase in housing construction is a result of demand created by other energy development projects and service related employment. The market is still behind demand and is not expected to reach its peak until 1990.

4.8.3 Community Services

Education Facilities

Meeker is in Rio Blanco County School District RE-1. The district had a total of 871 students in March 1980, as compared to 728 in fall 1976, a 20 percent increase. There are four schools in the district.

TABLE 4.8-2

POPULATION PROJECTIONS

	1977 Special Census	1981	1982	1983	1984	1985	1990	2000
Rio Blanco Co.	5,100	$\frac{5,459}{8,550}$	$\frac{5,359}{10,936}$	$\frac{5,619}{16,394}$	$\frac{5,698}{22,915}$	$\frac{5,779}{22,809}$ - 40,501	$\frac{6,575}{19,920}$ - 35,881	$\frac{6,973}{20,318}$ - 44,303
Meeker	1,848	$\frac{1,976}{4,528}$	$\frac{2,005}{6,517}$	$\frac{2,034}{9,398}$	$\frac{2,063}{11,291}$	$\frac{2,092}{13,532}$ - 16,745	$\frac{2,236}{11,366}$ - 14.125	$\frac{2,524}{11,654}$ - 16,593
Rangely	1,871	$\frac{2,004}{2,355}$	$\frac{2,033}{2,590}$	$\frac{2,062}{4,729}$	$\frac{2,091}{8,675}$	$\frac{2,121}{6,536}$ - 14,088	$\frac{2,267}{5,577}$ - 10,237	$\frac{2,559}{5,869}$ - 12,708
Rifle (Garfield Co.)	2,244	$\frac{2,745}{6,336}$	$\frac{2,858}{8,805}$	$\frac{2,971}{13,488}$	$\frac{3,084}{15,078}$	$\frac{3,197}{15,196}$ - 22,060	$\frac{3,761}{15,372}$ - 19,131	$\frac{4,889}{17,490}$ - 25,159

Legend: $\frac{A}{B}$ - C

A - Scenario I - Population growth without energy development.
B - Scenario II - Energy development projected with oil shale development as is currently planned.
C - Scenario III - Energy development projected with oil shale development with a high level of production of oil shale, 500,000 barrels a day by 1990 and 750,000 a day for years 1985, 1990 and 2000.

Source: Colorado West Area Council of Governments, 1980 Oil Shale Trust Fund Request, Rifle, Colorado.

Rifle is within the Garfield County School District RE-2. Enrollment was 1,605 in October 1976. The enrollment has increased to 1,812, a 19 percent increase since fall 1976.

The Rifle area has facility expansion planned due to the rapid increase in enrollment. The junior high school is being expanded for use as a senior high school, and the junior high school will move into the old senior high school building. Silt Elementary School is being expanded and a new elementary school is planned.

Education facilities and enrollment figures for the districts follow in Table 4.8-3.

Health Services

Meeker, Rangely and Rifle all have community hospitals, with a total capacity of 80 beds. Meeker has two doctors, Rangely three and Rifle four. Rifle has three dentists, while Rangely and Meeker each have one dentist. Rifle has a 50-bed nursing home in addition to its hospital. Meeker has a new Emergency Medical Treatment Team (EMTT) which utilizes a new ambulance staffed with paramedics.

In addition, mental health services are provided in two clinics, one located in Meeker with a full-time social worker and a secretary, and one in Rangely staffed with an alcohol counselor and a secretary/therapist (LPN).

Police and Fire Protection

All three cities have their own police departments. Meeker's consists of one chief, one senior officer, and three officers. Police protection in Rangely is provided by the chief and three officers. The department is supplemented by the County Sheriff's Deputies and Colorado Highway Patrol. Rifle has a larger force of one chief and ten officers. The municipal department is supplemented by the Garfield County Sheriff's Department and the Colorado Highway Patrol.

Meeker, Rangely and Rifle all have volunteer fire departments. All the towns have between 30 and 40 people who serve on the department. The fire ratings are 7 or 8 and are average for rural towns of their size.

4.8.4 Utilities

Meeker

The town of Meeker has adjudicated water rights of 10.42 cfs from the White River (CWACOG, 1975). This converts to 6.74 mgd available to the community.

The water supply system is owned by the town of Meeker. It has a capacity of 2.5 mgd, which will serve a population of approximately

TABLE 4.8-3

EDUCATION FACILTIES AND ENROLLMENT

	Grades	Enrollment
Rio Blanco County		
School District RE-1:		
Meeker Elementary	K-6	478
Rock Elementary	K-8	26
Barone Jr. High	7-8	129
Meeker Senior High	9-12	238
Total		871
School District RE-4:		
Rangely Elementary	K-5	244
Rangely Jr. High	6-8	100
Rangely Senior High	9-12	192
Total		536
Garfield County		
School District RE-2:		
Esma Lewis Elementary	K-6	587
Silt Elementary	K-5	195
New Castle Jr. High	K-8	327
Rifle Jr. High	7-8	204
Rifle Senior High	9-12	499
Total		1,812

Source: Rio Blanco School District Office, RE-1 & RE-4, 1980.
Garfield County School District Office, RE-2, 1980.

4,000 persons. With the addition of more wells, the ultimate capacity of the plant is 2.9 mgd, which could serve a population of 7,800.

Meeker's wastewater system is an activated sludge treatment plant. Improvements were made in 1976 to this system that increased the capacity to 400,000 gpd. The new facility should serve in excess of 4,000 people. Meeker now has a plan approved by EPA and committed funding through the Oil Shale Trust Fund to increase the serving capacity to 8,000 people (Johnson, pers. comm., 1980).

The town of Meeker and Rio Blanco County jointly operate a 41-acre designated landfill site four miles southwest of town. This site is used by a private hauler operating in Meeker, and residents hauling their own solid waste.

The White River Electric Association provides electricity for residential and commercial users in the Meeker area. Natural gas is supplied by the Western Slope Gas Company, and telephone service is provided by Mountain Bell.

Rifle

The water system is owned and operated by Rifle. The city presently has three sources of water: 1) Rifle Creek, which is used only for irrigation of the cemetery, 2) the Colorado River, and 3) Beaver Creek. There are two separate water treatment plants, Graham Mesa and Beaver Creek. The Graham Mesa plant is located northeast of town and pumps its water from the Colorado River to the plant. Treatment consists of a flocculation-settling tank, pressure filtration, and chlorination.

The Beaver Creek plant receives its water from Beaver Creek by means of gravity flow to the plant. Treatment includes flocculation, settling and gravity filtration. Two storage tanks are located near the Graham Mesa plant and one storage tank is located near the Beaver Creek plant. The distribution system consists of a grid of 4-, 6-, 8-, and 12-inch steel cast iron and asbestos cement pipe. The combined treated water capacity of the two plants is approximately 3.53 mgd (CWACOG, 1975).

The wastewater treatment system is owned and operated by the city of Rifle. There are approximately 860 sewer taps served by the city, a few of which are outside the city limits. The sewage collection system, which covers most of the developed part of the city, carries wastewater to a treatment plant consisting of a two-cell aerated lagoon and polishing pond. The sewage collection system has been installed over a period of many years and the present lagoon system was installed in 1966. The capacity of the system is expected to be realized in approximately two years (Merkle, pers. comm., 1978).

A recently completed wastewater treatment facilities plan for Rifle, recommended that the existing facility be improved to include the

addition of a third cell, which would accommodate increased population projected for the city. Currently, the city of Rifle is tripling the size of its wastewater treatment facility (Merkle, pers. comm., 1978). Its total planned capacity should serve a population of approximately 10,000. Rifle is currently receiving funding to to implement their expansion plans by the EPA and the Oil Shale Trust Fund (Johnson, pers. comm., 1980).

Garfield County and the City of Rifle operate a jointly designated sanitary landfill site several miles south of town. At the present time there are two trenches, one almost full, the other new. There is ample room for additional trenches at this site. Coverage occurs twice weekly (CWACOG, 1975).

The White River Electric Association provides electricity to residents of Rifle. Natural gas is supplied by the Western Slope Gas Company, and telephone service is provided by Mountain Bell.

4.8.5 Study Area Economy

The economy of Rio Blanco County is based primarily on mining and agriculture. These two sectors are considered basic to an economy in that most of the production from these activities is exported outside the county, with revenues imported into the county through employee payrolls, local purchases, corporate personal income, and retail sales and use taxation. This imported revenue supports secondary services (e.g., retail trade and services). Communities in the study area (i.e., Meeker, Rangely, and Rifle) have all developed as regional trade and service centers in support of these basic industries. Mining is expected to increase in importance as oil shale and coal resources are developed.

Total employment by sector in Rio Blanco County in 1977 and income characteristics are summarized in Appendix G. More recent data are not currently available.

Sixty-two percent of the employees work in the mining industry, with 966 persons employed in 48 operations. Median family income increased 4.3 percent from 1975 to 1976. The number of families below the poverty level remained the same although those earning over $15,000 increased by 3.1 percent and households earning between $10,000 and $14,999 increased by 3.6 percent.

Financial Resources

A summary of revenues and expenditures in Rio Blanco County is shown in Appendix G. The largest single source of revenue is the property tax, levied on all real estate according to assessed valuation. Other revenue sources include intergovernmental revenue (Federal General Revenue Sharing, State Highway Users Tax, permit fees and charges for services, etc.).

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Total employment by sector in Rio Blanco County in 1977 and income characteristics are summarized in Appendix G. More recent data are not currently available.

Sixty-two percent of the employees were in the mining industry, with 900 persons employed in 45 operations. Median family income increased 4.3 percent from 1975 to 1976. The number of families below the poverty level remained the same although those earning over $15,000 increased by 1.1 percent and households earning between $10,000 and $14,999 increased by 1.6 percent.

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4.8.6 Community Attitudes

Increases in oil shale development will bring additional prosperity to the region. However, people are increasingly questioning the effect it will have on the quality of their lives (Wall Street Journal, 1979).

"Quality of life" is defined as an individual's overall perceived satisfaction of his needs over a period of time. (Arnold Mitchell, et al., 1973). The basic assumption underlying this definition is that which people need, value and believe constitutes the dominant elements influencing their perception of quality of life. The quality of life as perceived by residents of the study area reflects a strong sense of community spirit. Lifestyles of local residents are closely tied to the land-based economy, which has fostered a sense of common experiences, values, and social habits.

A survey of attitudes towards growth was conducted in 1975 among residents of Meeker by the Rio Blanco County Planning Department. Questionnaires were distributed to all households in Meeker, and a 35 percent return (350 responses) was obtained.

Results indicated that residents of Meeker were aware that growth is inevitable. The major concern of the community was that growth be planned. When questioned as to a desired population level, 18 percent preferred no growth; 60 percent preferred a population increase of 3,000 to 5,000; 18 percent, 6,000 to 10,000; 3 percent, 10,000 to 15,000; and 2 percent over 15,000.

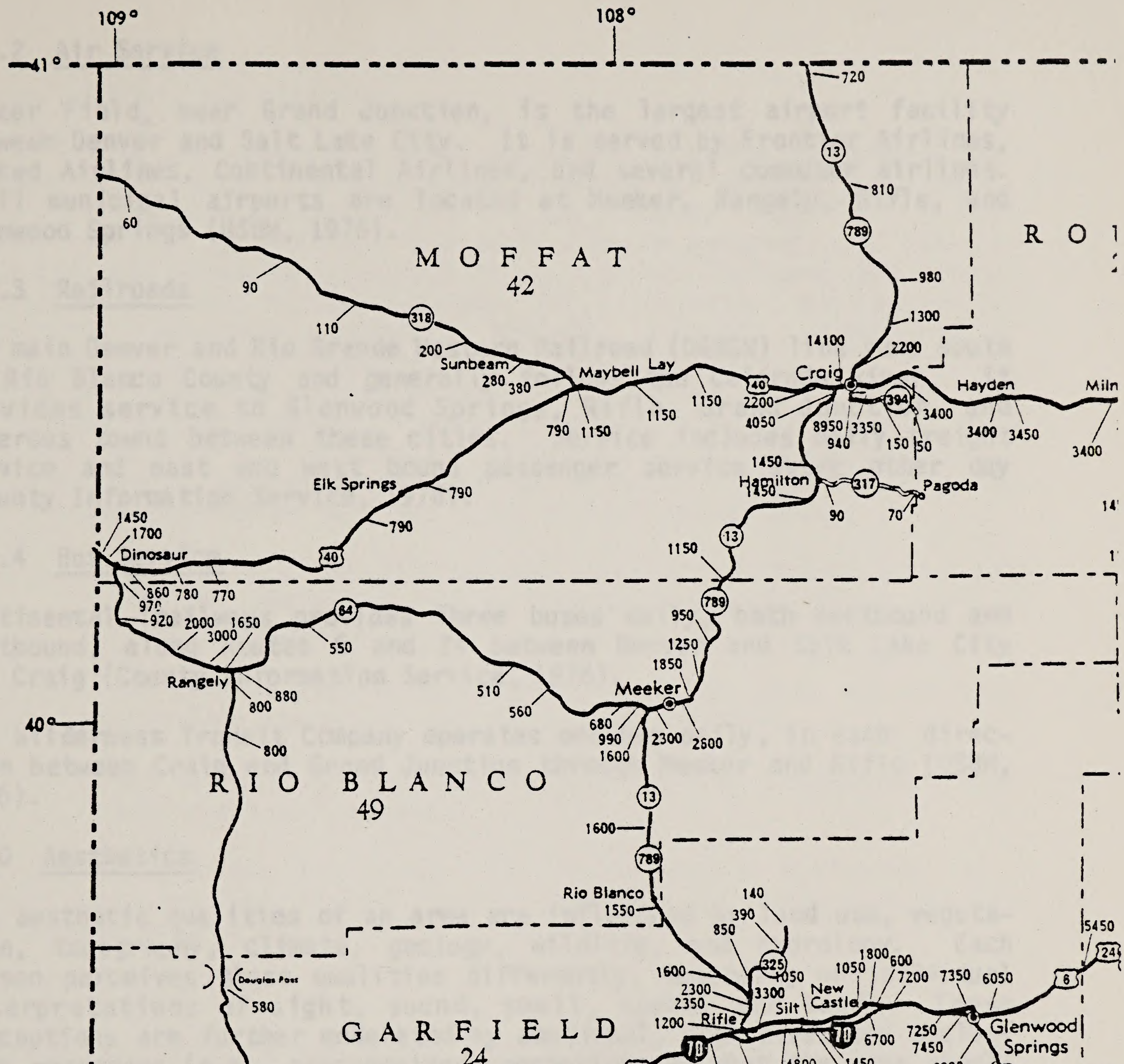
Respondents disagreed about where growth should be focused. Sixty-one percent thought that resource development should not occur in Meeker, and 51 percent responded favorably to the idea of a new town being established to accommodate resource development-related population.

4.9 Transportation

4.9.1 Highways and Roads

The USBM site is located approximately 3 km (2 miles) up Horse Draw from County Road 5. The road to the site is a gravel surfaced road which was improved by USBM. Horse Draw Road starts at the confluence of Piceance Creek and Horse Draw on County Road 5. County Road 5 is an all weather hard surfaced road (Tri-County, 1976). Traveling distance to Rangely from the site is approximately 80.5 km (50 miles); to Meeker it is 56.3 km (35 miles); to Rifle it is about 69.2 km (43 miles) (USBM, 1976).

Figure 4.9-1 illustrates 1976 Annual Average Daily Traffic Volumes for the major transportation routes in Rio Blanco and surrounding counties.



SOURCE:

"1978 Traffic Volume Map Colorado State Highway System", Colorado Department of Highways.

1978 TRAFFIC VOLUMES, RIO BLANCO COUNTY AND AREA

FIGURE 4.9-1

4.9.2 Air Service

Walker Field, near Grand Junction, is the largest airport facility between Denver and Salt Lake City. It is served by Frontier Airlines, United Airlines, Continental Airlines, and several commuter airlines. Small municipal airports are located at Meeker, Rangely, Rifle, and Glenwood Springs (USBM, 1976).

4.9.3 Railroads

The main Denver and Rio Grande Western Railroad (D&RGW) line runs south of Rio Blanco County and generally follows the Colorado River. It provides service to Glenwood Springs, Rifle, Grand Junction, and numerous towns between these cities. Service includes daily freight service and east and west bound passenger service every other day (County Information Service, 1976).

4.9.4 Bus Service

Continental Trailways provides three buses daily, both eastbound and westbound, along Routes 6 and 24 between Denver and Salt Lake City via Craig (County Information Service, 1976).

The Wilderness Transit Company operates one bus daily, in each direction between Craig and Grand Junction through Meeker and Rifle (USBM, 1976).

4.10 Aesthetics

The aesthetic qualities of an area are influenced by land use, vegetation, topography, climate, geology, wildlife, and hydrology. Each person perceives these qualities differently, depending on individual interpretations of sight, sound, smell, touch, and taste. These perceptions are further moderated by emotional, cognitive, and evaluative responses (e.g., preconceived conceptions of what the area should look like).

Aesthetic resources are defined in terms of landscape units. A landscape unit is an area of land with common distinguishing visual characteristics in the landform, rock formations, water forms, and vegetative patterns. The four elements competing for dominance in any landscape are form, line, color, and texture. Man-made deviations to landscape units can be either "positive" or "negative" depending on the degree of contrast to the characteristic landscape. Positive man-made deviations are not in conflict with the existing landscape unit, or blend in with the environment as in roads that conform to existing topography. Negative deviations are those man-made features that directly conflict with the existing landscape.

Three major landscape units were identified in the study area: bottomlands, uplands, and riparian.

Table 4.10-1 and Appendix H show the visual resource assessment management of the project area obtained from the BLM White River Resource Area Unit Resource Analysis (URA) for the Piceance Creek Planning Unit (Bouts, 1978). In addition, a visual resource assessment of the project area was conducted on August 26, 1978 by Mr. R. Myers, BLM outdoor recreation planner, Meeker, Colorado, Mr. T. Ciavonne, BLM Engineering Technician (landscape architect), Montrose, Colorado, accompanied by Mr. E.A. Jackson, VTN Consolidated, Irvine, California. The original URA visual resource assesment was performed by Mr. D. Bouts, BLM Recreation Planner, Meeker, Colorado, during 1978. The project area was given a Class III designation as being part of the Piceance Creek landscape unit. Upon completion of the August 26, 1978 assessment, the designation was changed to Class V for the following reasons:

- o The project facilities were present at the time of the original assessment and no further expansion of the facilities is contemplated.
- o The present facilities (except the access road) are not visible from the paved road along Piceance Creek.
- o The access road will be utilized only by project personnel and occasional hunters.

The project area was thus given a "C" scenic quality evaluation indicating the area has minimal scenic qualities in comparison to the surrounding area of analysis.

4.10.1 Landscape Units

Three major landscape units were identified in the study area: bottomlands, uplands and riparian.

Bottomlands Landscape Unit

The bottomlands comprise the flat to gently sloping flood plains of the intermittent streams. The valleys of Horse Draw and Ryan Gulch are the most prominent of this bottomlands unit. The dominant element in the bottomlands landscape unit is line, caused by the intermittent stream channels and steep terrace escarpments, as shown on Figure 1, Appendix H. When this landscape unit is viewed in closer proximity, as shown on Figure 2, Appendix H, texture and color start to compete for dominance. The most common vegetation in this landscape unit is the bottomland sagebrush communities which give this unit a mottled appearance. The best examples of this are seen along Horse Draw and its side gulches.

TABLE 4.10-1

VISUAL RESOURCE ASSESSMENT CRITERIA
OF THE USBM OIL SHALE RESEARCH TRACT

Landscape Unit	Visual Zone	Visual Sensitivity	Quality SQF	Quality SQE	Visual Contrast Rating/Management Class
Bottomlands					
Horse Draw	FG	Low	4	C	V
Ryan Gulch	FG	High	7	B	III
Uplands	MG & SS	Low	4	C	IV
Riparian (Piceance Creek)	FG	High	7	B	III

Source: BLM

Notes:

FG Foreground 0 - 1 mile
MG Middleground 1 - 5 to 8 miles
SS Seldom Seen 5 to 8 - 15 to 20 miles

Low
*Medium Based on user attitude surveys and vehicular traffic count in Piceance Creek Planning Unit.
High

SQF Scenic quality factors (see BLM descriptions in Appendix H)
SQE Scenic quality evaluation:
*A Outstanding
B Common
C Minimal

BLM Management Classes

*I National/primitive areas; no changes allowed
*II Unique scenic areas; changes only if not evident to casual observer
III Characteristic areas; changes only if subordinate to characteristic landscape
IV Characteristic areas; changes dominant but to be rehabilitated five years after project termination
V Characteristic areas; existing changes to characteristic landscape needing rehabilitation

* Do not occur in project area or immediately surrounding area.

Uplands Landscape Unit

The uplands landscape unit are the most prominent landforms of the study area, as shown on Figure 3 in Appendix H. The most distinct views in the area are from the plateaus that rise as much as 198 m (650 ft) over the surrounding landscape. These plateaus provide panoramic views that reveal the contrasts between the flat to gently rolling bottomlands, the cultivated area alongside the Piceance Creek landscape unit, and the moderately to steeply sloping hillsides and rock outcrops of the uplands, as shown in Appendix H.

Form is the dominant element in the uplands landscape unit (see Figure 3, Appendix H) with texture competing for dominance in some areas. The vegetation consisting of thinly scattered sagebrush and pinyon-juniper communities gives this landscape a slightly mottled and disordered appearance, and lends diversity to the landscape.

Riparian Landscape Unit

The riparian landscape unit is the area along Piceance Creek (see Figure 4, Appendix H). The land/water interface is the most prominent feature of this landscape unit. Line and color compete for dominance in different parts of the unit, particularly in the riparian and agricultural meadows vegetation communities, where the grasses, rushes, and sedges give the impression of an amber ocean of vegetations.

The aesthetic qualities of the study area change in the different seasons. In the winter, the drab tans, browns, and greys dominate the characteristic landscape, with texture (from vegetation), line (ephemeral streams and Piceance Creek), and form (plateaus and vegetation) competing in different areas of the site. In other seasons annual vegetation types appear, lending diversity and color to the characteristic landscape. During all seasons the characteristic landscape gives the feeling of openness and tranquility, particularly when wildlife (deer, rabbits) are viewed grazing or feeding.

The development of the 2.4 meter (8 ft) shaft has disturbed the natural tranquility of the area, as has development of the access roads and associated increased traffic levels; however, the disturbed areas represent only a small portion of the total study area, as shown on Figure 1, Appendix H.

4.11 Archaeology and Paleontology

The cultural and paleontological resource investigations conducted for the project have located 17 cultural sites and 22 paleontological sites. Two cultural (historic) and 7 paleontological sites are located outside the USBM Tract. None of the sites located has been previously recorded or nominated to the National Register of Historic Places (NRHP) or the National Registry of Natural Landmarks (NRNL). Four

Uplands Landscape Unit

The uplands landscape unit are the most prominent landforms of the study area, as shown on Figure 3 in Appendix H. The most distinct views in the area are from the plateaus that rise as much as 189 m (650 ft) over the surrounding landscape. These plateaus provide panoramic views that reveal the contrasts between the flat to gently rolling bottomlands, the cultivated area alongside the Pinenut Creek landscape unit, and the moderately to steeply sloping hillsides and rock outcrops of the uplands, as shown in Appendix H.

Form is the dominant element in the uplands landscape unit (see Figure 2, Appendix H) with texture competing for dominance in some areas. The vegetation consisting of lightly scattered sagebrush and pinyon-juniper communities gives this landscape a slightly mottled and dis-ordered appearance, and lends diversity to the landscape.

Riparian Landscape Unit

The riparian landscape unit is the area along Pinenut Creek (see Figure 4, Appendix H). The landwater interface is the most prominent feature of this landscape unit. Line and color contrast for landscapes in different parts of the unit, particularly in the riparian and agricultural meadows vegetation communities, where the grasses, rushes, and sedges give the impression of an upper ocean of vegetation.

The aesthetic qualities of the study area change in the different seasons. In the winter, the drab tans, browns, and grays dominate the characteristic landscape, with texture (from vegetation), line (ephemeral streams and Pinenut Creek), and form (plateaus and vegetation) competing in different areas of the site. In other seasons brought vegetation types appear, lending diversity and color to the characteristic landscape. During all seasons the characteristic landscape gives the feeling of openness and tranquility, particularly when wildlife (deer, rabbits) are viewed grazing or feeding.

The development of the 2.4 meter (8 ft) shaft has disturbed the natural tranquility of the area, as has development of the access roads and associated increased traffic levels; however, the disturbed areas represent only a small portion of the total study area, as shown on Figure 1, Appendix H.

4.11 Archaeology and Paleontology

The cultural and paleontological resource investigations conducted for the project have located 17 cultural sites and 12 paleontological sites. Two cultural (prehistoric) and 7 paleontological sites are located outside the USBM Tract. None of the sites located has been previously recorded or nominated to the National Register of Historic Places (NRHP) or the National Registry of Natural Landmarks (NRNL). Four

cultural sites (2 historic and 2 prehistoric) have been recommended by Dr. Jennings as being eligible for the NRHP. None of the paleontological sites is considered at this time to be of NRNL quality.

The cultural resource investigation was conducted under the direction of Dr. Calvin H. Jennings, Laboratory of Public Archaeology, Colorado State University (CSU) during July 1976. Although not contracted to inventory and evaluate historic sites, the investigators were to record any historic sites found. Two such sites were discovered (see 4.11.1 below). Dr. Peter Robinson, University of Colorado Museum, directed the paleontological investigation. The cultural and paleontological study areas are shown in the investigators' reports (Figure 1 and Figure 2, Appendix I).

4.11.1 Cultural Resources

Historic Resources

Although a number of historical sites are located in the regional study area, none are recorded in the development site. Two historical sites were located by Mr. Kim Pinkerton (CSU) during the archaeological investigation. These sites, Ryan Gulch School and Miller Hill Cemetery, are located outside of the USBM tract. Neither of these sites is listed on the NRHP as yet; however, NRHP nomination forms are being submitted.

Historic sites in Rio Blanco County that are currently listed on the NRHP are listed below:

Meeker vicinity. ST. JAMES EPISCOPAL CHURCH, 368 4th St., (3-30-78)

Meeker vicinity. BATTLE OF MILK RIVER SITE, 17 mi. NE of Meeker on Thornburgh Rd., (8-22-75)

Meeker vicinity. DUCK CREEK WICKIUP VILLAGE, 36 mi. SW of Meeker, (11-20-75)

Rangely vicinity. CANON PINTADO, 12 mi. S of Rangely on CO 139, (10-5-75)

Rangely vicinity. CARROT MEN PICTOGRAPH SITE, 17 mi. SW of Rangely off Rangely Dragon Rd., (8-22-75)

Rangely vicinity. FREMONT LOOKOUT FORTIFICATION SITE, (11-20-75)

The narrative on cultural resources, primarily excerpted and summarized from An Isolated Empire: A History of Northwest Colorado prepared by Frederic J. Athearn as part of the Bureau of Land Management, Colorado, Cultural Resources Series (No. 2, Historical), is included in Appendix I.

Prehistoric Resources. Fifteen sites and 23 isolated finds (locales with fewer than 5 artifacts) were found in the USBM tract. Two sites (5RB319 and 5RB323) were recommended by the investigator as being eligible for the NRHP. Nine sites (5RB310, 316, 317, 320, 321, 322, 325, 326 and 452) were found to contain supplemental information concerning aspects of the region's prehistory. The remaining 4 sites have no value for further interpretive information beyond that recorded by the investigation. The sites inventoried during the investigation are summarized in Appendix I.

The results of the archaeological investigation indicate that the USBM tract was occupied during the mid-Archaic (5,000 B.C. to A.D. 700) and Protohistoric (A.D. 1500 to historic contact) periods. The types of sites and artifacts indicate the area was utilized for hunting game and collecting edible plant foods on an infrequent basis, possibly seasonally. No evidence was located indicating utilization by sedentary horticulturalists such as the Fremont or Anasazi (A.D. 700 to A.D. 1300) cultures to the west and south.

The diagnostic cultural material located during the investigation indicates that prehistoric occupation and/or utilization of the project area was minimal during late Archaic and Protohistoric periods. For the late Archaic period this material includes a corner-notched projectile point similar to styles dating back to 1250 B.C. and another one with a style dating prior to 2000 B.C. (Appendix I). Protohistoric Shoshonean occupation is represented by site 5RB319. Diagnostic material includes a suspected Teepee ring, Shoshoni Ware pottery sherds and one metal bead.

The lack of certain types of evidence precludes interpretations beyond those given above although there is limited evidence suggesting occupation during early Archaic times. The evidence includes the latter projectile point style mentioned above which has been found in sites dating back to 7000 B.C. and a bison skull (Appendix I, site V9). The skull was located during the paleontological investigation immediately adjacent to the project area. The rear portion of the skull is missing. Prehistoric hunters are known to have removed the rear of a bison skull to extract the brain for consumption during the butchering process. The rest of the cultural material -- the remaining projectile points, bifaces, scrapers, utilized flakes, choppers, drills, manos and metates, and lithic debitage (stone flakes left from tool preparation) -- are known in the archaeological record of Archaic through historic aboriginal period sites. The function or use of the rectangular pit in site 5RB319 could not be determined.

Beyond the interpretations given above, identifying more specific cultural chronologies and lifeways (economic, social, etc.) is not possible. This is due principally to three factors. One is that a number of the sites are small and correspondingly yield small amounts of surface material. Secondly, some sites have been extensively

Prehistoric Resources. Fifteen sites and 22 isolated finds (locales with fewer than 5 artifacts) were found in the USBM tract. Two sites (5RB319 and 5RB323) were recommended by the investigator as being eligible for the NRHP. Nine sites (5RB310, 316, 317, 320, 321, 322, 325, 326 and 4581 were found to contain supplemental information concerning aspects of the region's prehistory. The remaining 4 sites have no value for further interpretive information beyond that recorded by the investigation. The sites inventoried during the investigation are summarized in Appendix I.

The results of the archaeological investigation indicate that the USBM tract was occupied during the mid-Archaic (5,000 B.C. to A.D. 700) and Protohistoric (A.D. 1500 to historic contact) periods. The types of sites and artifacts indicate the area was utilized for hunting game and collecting edible plant foods on an infrequent basis, possibly seasonally. No evidence was located indicating utilization by sedentary horticulturalists such as the Fremont or Anasazi (A.D. 700 to A.D. 1300) cultures to the west and south.

The diagnostic cultural material located during the investigation indicates that prehistoric occupation and/or utilization of the project area was minimal during late Archaic and Protohistoric periods. For the late Archaic period this material includes a corner-notched projectile point similar to styles dating back to 1200 B.C. and another one with a style dating prior to 2000 B.C. (Appendix I). Protohistoric Shoshonean occupation is represented by site 5RB319. Diagnostic material includes a suspected Tenpee ring, Shoshoni ware pottery sherds and one metal bead.

The lack of certain types of evidence precludes interpretations beyond those given above although there is limited evidence suggesting occupation during early Archaic times. The evidence includes the latter projectile point style mentioned above which has been found in sites dating back to 7000 B.C. and a bison skull (Appendix I, site 326). The skull was located during the paleontological investigation immediately adjacent to the project area. The rear portion of the skull is missing. Prehistoric hunters are known to have removed the rear of a bison skull to extract the brain for consumption during the butchering process. The rest of the cultural material — the remaining projectile points, bifaces, scrapers, utilized flakes, choppers, drills, manos and metates, and lithic debitage (stone flakes left from tool preparation) — are known in the archaeological record of archaic through historic aboriginal period sites. The function or use of the rectangular pit in site 5RB319 could not be determined.

Beyond the interpretation given above, identifying more specific cultural chronologies and lifeways (economic, social, etc.) is not possible. This is due principally to three factors. One is that a number of the sites are small and correspondingly yield small amounts of surface material. Secondly, some sites have been extensively

disturbed on the surface by chaining activities. Artifacts which would otherwise be observed have been buried in the soil or covered by dead vegetation. Third is the problem of relic hunters who collect artifacts from the surface which are most valuable archaeologically for establishing chronology. This is especially noticeable at 5RB319. Further subsurface testing (excavations to recover additional cultural artifacts and features and datable material) would be needed to determine the full nature and extent of the prehistoric resources located to date.

4.11.2 Paleontological Resources

The paleontological resources located during the investigation include fossils of plants, invertebrates, and vertebrates. All the resources were found in the exposures of the Green River and Uinta formations of the Eocene Epoch except one find which was in Quaternary alluvium. The lithology and depositional environments are described in Section 4.4, Geology, in greater detail.

Twenty-four paleontological sites were discovered by the investigators. The types of fossils and their distribution among the formations are presented in Table 4.11-1. Refer to Appendix I for the description and evaluation of each site.

All of the sites located have important paleontological research values because they are of rare and well-preserved specimens or indicate other resources of the same values may exist in subsurface deposits. Some well preserved paleo-botanical specimens were found in the Green River and Uinta Formations. Eight sites contain leaf fossils and one contains algae fossils. While the insect larvae specimens (site I_1) are poorly preserved, well-preserved ones may be found in subsurface deposits. Vertebrate fossils from Piceance Creek Basin, especially the Titanothere specimens, are important because the upper Eocene was a time when many important changes were occurring in the evolution of mammals. Large mammal fossils of the Eocene Epoch have received little scientific study since World War I. The one find in Quaternary alluvium consists of a single bison skull. None of the sites are of NRNL quality because the sites do not contain large concentrations of fossil specimens amenable to interpretation for public use.

TABLE 4.11-1

DISTRIBUTION OF FOSSIL TYPES

	Green River	Uinta 4	Uinta 5	Quarternary	Total
Plants	4	5	3		12
Invertebrate		1			1
Vertebrate (Mammal)	___	___	10	1	11
	4	6	13	1	24

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SECTION 5.0

ENVIRONMENTAL CONSEQUENCES

This section discusses the impacts which would occur should the proposed project be implemented at the existing USBM Oil Shale Mining Research Facility. Impacts are described and where possible, are quantified in relation to specific aspects of the planned development.

Both site-specific and larger community and regional impacts are addressed, as appropriate to each discipline. As discussed in the Summary (Section 1.0), it should be noted that the 9 ha (22 ac) project site is an impacted environment having already undergone considerable modification with construction of an access road, buildings, and other facilities over the past several years. For this reason, some site-specific impacts would be inconsequential as they have, in essence, occurred as a result of previous development activities. In these instances, effects of the proposed project would be negligible. A discussion of these existing facilities is presented in Section 3.0.

5.1 Ecology

5.1.1 Vegetation

The proposed project would create few, if any, impacts to vegetation, as the activities would occur on an area which has already been affected by removal of vegetation from 7.4 ha (18.4 ac) and disturbance of vegetation on an additional 1.5 ha (3.8 ac). A slight decrease in productivity may occur, however, as dust which is generated on the site and the access road is deposited on nearby vegetation.

5.1.2 Wildlife

Impacts on wildlife resulting from previous activities were not serious. The primary impact to wildlife from this project is anticipated to be an increase in deer road kills along Rio Blanco Road, along State Highway 64 between Meeker and the Rio Blanco Road and State Highway 13 between Rifle and Rio Blanco. This impact would result from a projected increase of about 40 vehicle trips per day in an area of heavy winter deer use. It is not possible to quantify this incremental increase in deer mortality due to the complexity of the problem and the lack of adequate existing site specific data. However, road kills can reasonably be expected to be greatest during spring migration (March through May) and autumn migration (October through November) and would most likely occur during the evening and morning hours.

Some local impact on wildlife, particularly raptors and waterfowl, is expected to result from operational activities, noise, traffic and potential illegal shooting. The degree of this disturbance cannot be predicted or quantified but it is not expected to constitute a significant problem.

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Additional impacts are expected off-site. These include an increase in wildlife disturbance, poaching incidents, and possible habitat loss in other areas due to housing construction. The degree of these disturbances cannot be predicted but is anticipated to be of much less magnitude than those associated with other larger, longer term mining operations in the Piceance Basin.

No endangered or threatened animal species are expected to be adversely affected by the project.

5.1.3 Aquatic Ecology

The proposed project should not have a measurable impact on the hydrology or quality of Piceance Creek (see Sections 5.4, Surface Hydrology and 5.5, Ground Water Hydrology for further information). Therefore, it is not anticipated that the proposed project would result in measurable impacts to aquatic ecology.

5.1.4 Effects Following Reclamation

The reclamation plan proposed for the USBM site (Appendix A), prepared by Williams Brothers Engineering (1979) is designed to restore the disturbed area to rangeland and wildlife habitat. The plan includes grading the site to approximate original contours and revegetating with appropriate species. Grassland-saltbush species will be planted on south and west slopes; desirable browse species, including bitterbrush and mountain mahogany, will be used on the rest of the site. Pinyon, juniper and other native tree species occurring in the area will be planted in the disturbed area. Revegetation techniques include use of a Rangeland drill supplemented by broadcast seeding in rocky areas and transplanting tree species. Sewage sludge or other organic material will be used to improve the soil of the disturbed areas, and fertilizer will be applied in the fall after the first growing season and at lower levels after the second season, if necessary. Rainfall is considered adequate to support the new vegetation and no irrigation program has been planned. All reclamation will be completed within five years from the date of initiation of reclamation activities. The reclamation plan is to be initiated the first fall following final disturbance of the area.

Successful implementation of the proposed reclamation plan is expected to reduce the period of adverse impact to wildlife which has occurred due to habitat loss, by accelerating the redevelopment of wildlife habitat on the project site.

Revegetation success is generally dependent upon a variety of factors including species seeded, the amount, timing and method of seeding, soil and slope conditions, and in many cases, mulching, fertilization and water, particularly natural precipitation. Therefore, the degree of success is not easily predictable and efforts in the general region

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Successful implementation of the proposed reclamation plan is expected to reduce the period of adverse impact to wildlife which has occurred due to habitat loss, by accelerating the reestablishment of wildlife habitat on the project site.

Revegetation success is generally dependent upon a variety of factors including species seeded, the amount, timing and method of seeding, soil and slope conditions, and in many cases, mulching, fertilization and water, particularly natural precipitation. Therefore, the degree of success is not easily predictable and efforts in the general region

of the project have not always been successful. However, experience in revegetation at nearby Federal Oil Shale Lease Tract C-a indicates that revegetation to levels of vegetation cover equal to native (pre-project) conditions can be achieved (Rio Blanco Oil Shale Co., 1980). Moreover, previous BLM reseeding efforts (using primarily crested wheatgrass) in chained pinyon-juniper areas in the Piceance Basin area have generally been successful (Maguire, 1980).

5.2 Air Quality

5.2.1 Emission Estimates

Air quality in the project area will be affected primarily by fugitive dust and point source emissions. Fugitive dust emissions will be generated by loading and unloading of the ore and traffic on unpaved access and haul roads. Point source emissions will be from internal combustion engines, oil fired boilers, recycle gas heater, diesel-driven air compressors, and shaft ventilation. Trace metals may be released to the atmosphere due to combustion of gases generated during pyrolysis and char gasification.

Fugitive Dust Emissions

The primary source of fugitive dust emissions are: 1) ore handling from stockpile to crusher; 2) ore handling from crusher to the shaft; 3) traffic on unpaved access and haul roads. The estimated uncontrolled emissions from these operations are presented in Table 5.2-1. Total fugitive dust emissions are estimated to be about 54 tons. The assumptions and calculations used to compute these emission rates are presented in Appendix B.

5.2.2 Combustion Emissions

The primary sources of combustion emissions are oil-fired steam generators and diesel-powered generators and air compressors. Table 5.2-2 presents the estimated combustion emission rates. The assumptions and calculations used to compute these emission rates are presented in Appendix B.

5.2.3 Mine Ventilation Exhaust Emissions

The estimated particulate emissions from shaft ventilation exhausts are estimated to be 2.6 tons.

5.2.4 Trace Elements

Retort gases which provide heat for pyrolysis and char gasification may contain very small amounts of metallic and heavy elements. Therefore, the pyrolysis and char gasification operation may produce trace metals. Preliminary measurements of the composition of retort off-gases made by Laramie Energy Technology Center indicate the presence of arsenic, mercury, iron, chromium and zinc. The concentrations of these elements in gaseous and particulate forms are presented in Table 5.2-3.

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TABLE 5.2-1

FUGITIVE DUST EMISSIONS

		Tons
1. Ore handling from stockpile to crusher		
a. Loading ore into a front end loader		0.84
b. Dumping ore into the crusher		0.05
2. Ore handling from crusher to shaft		
a. Dumping crushed ore into the shaft		0.84
3. Traffic on unpaved roads (haul roads)		0.38
4. Traffic on unpaved access roads		51.0
5. Transportation of oil on unpaved roads		0.65
	Total	53.76

Source: VTN estimates, 1980.

TABLE 5.2-2

COMBUSTION EMISSIONS
(Tons)

	Pyrolysis	Boilers	Diesel Generators and Air Compressors	Shaft Ventilation	Total
Particulates	0.01	0.003	1.32	2.58	3.91
SO_2	0.01	0.07	1.15	N/A	1.23
CO	0.01	0.009	12.54	N/A	12.56
HC	0.002	0.002	24.56	N/A	24.56
NO_x	0.09	0.038	189.76	N/A	189.89
Aldehydes	N/A	N/A	0.25	N/A	0.25

N/A Not Applicable

Source: VTN estimates, 1980.

TABLE 5.2-3

LEVELS OF MINOR ELEMENTS IN OFF-GAS FROM LERC 10-TON RETORT

Element	Form	Concentration in Off-Gas (ug/SCM)
Arsenic	Gas	15.00
	Particulate	0.40
		15.40
Mercury	Gas	2.20
	Particulate	0.15
		2.35
Iron	Gas	120.00
	Particulate	6.00
		126.00
Chromium	Gas	90.00
	Particulate	2.00
		92.00
Zinc	Gas	40.00
	Particulate	0.50
		40.50

Notes: 1) Assumes net gas production of 500 SCM/ton shale.

2) Gaseous forms are defined as those not collected by a 0.5u neopore filter.

Source: EPA, 1977.

5.2.5 Estimated Pollutant Concentrations

Air quality impacts from particulates, SO_2, CO, HC and NO_x were calculated using the assumptions outlined in Appendix B. Stability Class F was selected to predict worst case maximum 1-hour concentrations.

The total ground level concentrations for particulates, SO_2, CO, HC and NO_x are presented in Table 5.2-4. The background concentrations for particulates and SO_2 were assumed to be 25 and 20 ug/m^3, respectively (EPA, 1978); the background concentrations for CO, HC and NO_x were assumed to be insignificant. Comparison of the total ground level concentrations with the state and federal standards are shown in Table 5.2-5.

If the 1-hour concentration is averaged over a longer period, e.g. 2-hour, 24-hour or annual, then the resultant concentration for particulates, SO_2, CO, HC and NO_x will be considerably lower than those presented in Table 5.2-5. Therefore, the impacts of these constituents on the air quality are expected to be minimal.

5.3 Noise

During the Process Testing phase of the project, four main sources of noise will be generated at the project site: 1) air compressors; 2) ventilation fans; 3) generators, and 4) crushing equipment. Each of these sources and their cumulative impacts are addressed below.

5.3.1 Compressors

The project will use three compressors. A 50 hp slipstream compressor will be run to determine the amount of light condensibles present in the product gas. Noise generated by the slipstream compressor will be 72 dBA at 10 feet. Additional air compressors will be operated near the turbo fans. Noise generated by these compressors will be 79 dBA at 10 feet.

5.3.2 Ventilation Exhaust Fans

Three axial turbines are connected in series to give a total of 35,000 CFM. These consist of two Joy 100 hp fans and one Joy 200 hp fan, located approximately 40 feet west of the shaft. No data are available on noise generated by fans of this size. However, noise from these sources should be minimal.

Generators

There will be four diesel-driven electric generators at the project site, with three in operation and on as stand-by. The 440 KW, 750 KW and 2,000 KW generators will be operational, with the second 2,000 KW generator providing backup. These generators will be in operation 24 hours per day, 7 days per week. The noise levels generated from each operating generator is shown in Table 5.3-1.

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Generators

There will be four diesel-driven electric generators at the project site, with three in operation and one on stand-by. The 480 KW, 750 KW and 2,000 KW generators will be operational, with the second 2,000 KW generator providing backup. These generators will be in operation 24 hours per day, 7 days per week. The noise levels generated from each operating generator is shown in Table 5.3-1.

TABLE 5.2-4

TOTAL GROUND LEVEL CONCENTRATIONS

	Calculated Ground Level Concentrations Averaged Over 1 Hour (ug/m^3)	Background Concentration (ug/m^3)	Total Concentration (ug/m^3)
Particulates	10.21	25	35.21
SO_2	5.44	20	25.44
CO	27.23	Insignificant	27.23
HC	49.01	Insignificant	49.01
NO_x	393.49	Insignificant	393.49

Source: VTN estimates, 1980.

TABLE 5.2-5

COMPARISON OF THE TOTAL GROUND LEVEL CONCENTRATIONS WITH THE STATE AND FEDERAL STANDARDS

	Total Ground Level Concentration, 1 Hour (ug/m^3)	Standard (ug/m^3)
Particulates	35.21	160 (24-hrs.)
SO_2	25.44	365 (24-hrs.)
CO	27.23	40,000 (1-hr. max.)
HC	49.01	160 (3-hr. max.)
NO_x	393.49	100 (Annual arithmetic mean

Source: VTN estimates, 1980.

TABLE 5.3-1

EQUIPMENT NOISE LEVELS

	Sound Level dBA
Crushing Facility (Hazeg impactor, 30 tph	106[c]
Diesel Gennerators:	
2,000 KW	108[b]
750 KW	106[b]
440 KW	106[b]
Ventilation Fans:	
(2) Joy 100 hp	a
(1) Joy 200 hp	a
Compressors:	
1,000 SCFM	78[d]
600 SCFM	79[d]
100 SCFM	72[d]

a) No data available
b) Source: Lawless Detroit Diesel
c) Source: Mesa Noise Lab
d) Source: Accurate Air Engineering

5.3.3 Crushing Equipment

There will be one portable crusher in operation at the site, a 30 tph Haze Mag impactor which will be in operation 24 hours per day, 7 days per week. It is estimated that this equipment will be in operation for about three weeks in the early part of the 2-1/2 month operations phase, or until the 14,000 tons of rock have been crushed.

5.3.4 Cumulative Effect of All Equipment

The cumulative effect of all noise sources within the project area will be a noise level of 92.8 dBA at a point about mid-way between the ventilation fans and diesel generators. This noise level assumes equipment is not shielded in any manner. Noise levels would be much lower if equipment were housed. Attenuation of sound due to spherical divergence would reduce the sound level to natural background within 2,500 feet of the noise generators.

5.4 Geology and Soils

5.4.1 Geology

Construction of the access road and work and material storage pads have previously resulted in modification of the physiography of 9.0 ha (22.2 acres) in the USBM tract. The work and materials storage pads are located in slight to moderately sloping stable terrain. Geologic strata have been buried on 5.7 ha (14.2 ac).

This project would not result in significant amounts of additional physiographic modifications of the USBM tract.

The USBM tract is located in a region of low seismicity, i.e., occurrence of up to one event equal to or greater than 5.0 on the Richter Scale per decade per 77,700 km^2 (30,000 mi^2). No known active faults are in or near the USBM tract. Although the probability of occurrence is small, an earthquake of intensity 5.0 or greater on the Richter Scale in the vicinity of the USBM tract could result in the spill of fuel oil and leachate from the holding ponds at the project site. These materials would reach the alluvial aquifer and could reach Piceance Creek, impacting water quality and aquatic ecology if the event coincided with stream flow in Horse Draw (see Section 5.6.4).

5.4.2 Soils

Construction of roads and pads in the USBM tract have previously resulted in the loss by mixing or burial of the soil materials from 7.4 ha (18.4 ac). Past disturbance of vegetation has lead to increased rates of erosion of topsoil from an additional 1.5 ha (3.8 ac). Because this project will not require a significant amount of additional physiographic modification, the effect on soils will be insignificant.

5.5 Surface Hydrology

Previous activities at the project site have had some impact on the surface water system of the USBM tract. The proposed activities, however, are not expected to significantly affect the existing environment. The greatest impacts would occur in the unlikely event of accidental leaks or spills.

5.5.1 Effect on Piceance Creek

The proposed research activities are expected to have no effect on nearby surface waters, due primarily to the "closed system" nature of the processing technology. A water holding pond located on the site (see Section 3.0) will contain approximately 1,892 m^3 (500,000 gal) of water and other fluids. The primary concern is a spill or leak of fluid from the pond after or during their use in the mining process, at which time the fluid may be referred to as leachate. Because the pond is constructed below the land surface, a spill resulting from failure of containing walls is not possible. Therefore, the most likely loss of leachate would be by leakage from the pond (see Section 5.6).

It is difficult to predict the exact concentration of chemical constituents in the holding pond. Given the available information (Slauson, 1979 and Rox, 1979) the major cations and anions are expected to be: bicarbonate, sodium, chloride, potassium and sulfate. The background groundwater TDS profile for the area (Dale and Weeks, 1978) ranges from 800 ppm to 4,000 ppm. The shale leachate TDS valves can range from 970 - 17,330 ppm (Harbert, Berg, McWhorter, 1979). With the above valves, and mass transfer processes taking place, the resulting TDS of the water in the holding pond may range from 970 ppm to 17,330 ppm.

Due to the below ground configuration of the holding pond, an embankment failure is virtually impossible. Also, there is minimal possibility of bank overflow, as the 3,785 m^3 (1,000,000 gal) capacity pond will contain a maximum of 1,892 m^3 (500,000 gal) of process fluids. Additionally, surface water flows due to precipitation events would be intercepted by a 0.6 m deep by 1.2 m wide (2 ft x 4 ft) diversion ditch designed to contain a 10 cm hr (4.5 in) (Multi Mineral Corporation, 1980). In order to affect Piceance Creek, a surface discharge would have to coincide with an ephemeral flow in Horse Draw of sufficient magnitude that transport to Piceance Creek would occur. In addition, it should be noted that the total 1,892 m^3 (500,000 gal) of process fluids represent only 4 percent of the daily average runoff of Piceance Creek. There is, however, the potential for increased stream flow resulting from annual disposal of up to 616 m^3 (0.5 ac-ft) of sanitary wastewater through a septic tank and leach field (see 5.6 Ground Water).

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It is anticipated that the proposed project would result in increased sediment yield from disturbed areas along the access road and haul

roads in the vicinity of the project site. This increase would occur during the construction phase of the project. It is estimated that project operation would result in a decrease in sediment yield from the current 97 tons per year (Frickel, et. al., 1975) to 24 tons per year. It is likely that the demobilization phase would yield a sediment load greater than that produced during the operations phase.

Impacts to water quality are expected to be minimal. There is a potential for surface water degradation from disposal of sanitary wastewater, spills, and leakage of fuels and high saline water. However, any spills would be diluted via runoff and would not significantly affect water quality.

Also, degradation by percolation to ground water is unlikely due to the length of time (more than 100 years) and filtering which would occur before such water could be transported via Horse Draw to Piceance Creek (see 5.6).

5.5.2 Erosion Effects

The construction of the access road, ore storage pads and related project activities have resulted in a modification of the physiography of the USBM tract area. However, the disturbed area is only 9.0 ha (22 acres) and therefore potential erosion effects associated with this area would be insignificant. The proposed project is not expected to create additional erosion potential beyond that which has been induced by previous activities on the site. The potential increase in suspended sediment levels in Horse Draw or Piceance Creek via erosion, would therefore be insignificant.

5.5.3 Run-Off Effect on Ore Storage Piles

According to the project plans (Multi Minerals, 1979) runoff will be diverted from the ore storage piles via a drainage control system around them. In addition, the ore storage piles will be covered with reinforced plastic sheeting and ditched to prevent contact with surface runoff to prevent dissolved constituents from migrating into the drainage channel. However, should chemical constituents find their way into the channel, the local influence via Horse Draw would be minimal, due to dilution effect of Piceance Creek (see 5.5.1, 5.6).

5.5.4 Run-Off Effect on the Evaporation Pond

The project plans include construction of a diversion channel surrounding the holding pond, thus controlling any surface run-off effect on the holding pond.

5.5.5 Effects Following Reclamation

The proposed USBM Reclamation Plan presented as Appendix A (Williams Brothers Engineering, 1979) is designed to restore the project site to

its original characteristics. The demobilization plans (shaft sealing, continued sump operation) which would precede this effort will contribute to total reclamation.

Reclamation procedures call for the control of runoff from affected areas by stabilizing with either rock or vegetation. Larger rocks will be placed along the bottoms of gullies and gulches. These rocks will act as energy dissipators. They will slow the movement of water through these areas, thereby increasing infiltration rates and reducing soil erosion. There would be no effect on either surface water hydrology or water quality following reclamation.

5.6 Ground Water Hydrology

5.6.1 Effects of Water Extraction From the Leached Zone

The project processing activities will require a total of about 1,892 m^3 (500,000 gal - 1.54 ac-ft) of water. During the three-month process, water requirements will be met by pumping water from the leached zone (lower aquifer) from a well located on the project site. In addition to water from the leached zone, approximately 303 m^3 (80,000 gal) of water are expected to be released by dissolution of hydrated minerals within the oil shale during pyrolysis. There are no other users of leached or saline zone ground water within two miles of the project area.

The mean annual runoff from Piceance and Yellow Creeks has been estimated to be 15,650 acre-feet. Assuming that 80 percent of the runoff results from ground water discharge, the groundwater baseflow is estimated to be 12,500 acre-feet per year (Weeks, et al., 1974). The amount of ground water to be extracted for the project mining process is minimal and therefore would not significantly affect the local hydrology or the regional hydrology of the Piceance Creek Basin.

5.6.2 Effect of Leaching Process and Pyrolysis Processes on the Stope

The pyrolysis, gasification and leaching process will not alter the physical and chemical properties of the stope. There are two influencing factors. The first factor involes the physical and chemical properties of the stope. The saline zone is impermeable and "structurally competent." The remaining interstitial water will not migrate from the stope (laterally or vertically).

The second factor is the nature of reactants and resulting products during pyrolysis. The pyrolysis process will occur at a temperature between 500°C and 650°C.

The pyrolysis process results in silicate formation at >800°C. This influences dissolution potential through the stope and is a significant deterrent to solubilization of many constituents, due to the presence of silica. This phenomena also contributes to stope wall stability.

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The second factor is the nature of reactants and resulting products during pyrolysis. The pyrolysis process will occur at a temperature between 500°C and 550°C.

The pyrolysis process results in silicate formation at >500°C. This influences dissolution potential through the stope and is a significant deterrent to solubilization of many constituents, due to the presence of silica. This phenomena also contributes to stope wall stability.

5.6.3 Effect of Leaching through Stope on Ground Water

The pyrolysis, gasification and leaching process will not significantly alter the properties of the stope, located in the lower part of the saline zone of the Parachute Creek member. Because of the impermeable and structurally competent properties of the saline zone, the remaining interstitial water (estimated to be 50,000 gallons; MMC, 1979) will not migrate from the stope laterally or vertically. There are approximately 213 m (700 ft) of impermeable saline rock between the top of the stope and the lower aquifer of the Parachute Creek member. There are no known significant aquifers below the bottom of the stope which may be affected. The underlying bedrock units are comprised of portions of the saline zone of the Parachute Creek member and the Garden Gulch and Douglas Creek members of the Green River formation. They are relatively impermeable, do not contain significant amounts of water, and act as confining beds.

5.6.4 Seepage Effects from Holding Pond

A water holding pond located on the site (see Section 3.0) will contain approximately 1,892 m^3 (500,000 gal) of water and other fluids. The primary concern is a spill or leak of fluid from the pond after or during their use in the mining process, at which time the fluid may be referred to as leachate. Because the pond is constructed below the land surface, a spill resulting from failure of containing walls is not possible. Therefore, the most likely loss of leachate would be by leakage from the pond.

Water stored in this pond will be pumped primarily from the leached zone. The pond will be divided into two equal parts. One-half will be used to store leach water and carbon recovery cooling water, estimated to be 1,514m^3 (400,000 gal). The other half of the pond will be used to store pyrolysis cooling water, an estimated 303 m^3 (80,000 gal) of water produced by the pyrolysis process from the saline zone, plus 176 m^3 (20,000 gal) of leached zone water. Because of the relatively large amount of water involved in the last six days of the pyrolysis process, there may be insufficient time for complete separation of the oil and water in the oil-water storage tank. If this occurs, it will be necessary to temporarily release the oil and water mixture into the holding pond. This oil would be pumped back to the storage tank by a skimmer after separation.

The holding pond will be lined with an impermeable man-made liner. Under normal conditions no leakage or other accidental discharge will occur. However, if a leak or spill of the leachate from the pond would occur, it would flow either as surface runoff down-slope and into Horse Draw or infiltrate the bedrock and alluvium, gradually reach the water table of the upper aquifer. Normally a surface spill would infiltrate the highly fractured bedrock without moving a very great distance down-slope and into Horse Draw. Horse Draw is an ephemeral stream; therefore, the only conceivable method for a spill to reach

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5.6.4 Seepage Effects from Holding Pond

A water holding pond located on the site (see Section 3.0) will contain approximately 1,892 m^3 (500,000 gal) of water and other fluids. The primary concern is a spill or leak of fluis from the pond after or during their use in the mining process, at which time the fluis may be referred to as leachate. Because the pond is constructed below the land surface, a spill resulting from failure of containing walls is not possible. Therefore, the most likely loss of leachate would be by leakage from the pond.

Water stored in this pond will be pumped primarily from the leached zone. The pond will be divided into two equal parts. One-half will be used to store leach water and carbon recovery cooling water, estimated to be 1,514m^3 (400,000 gal). The other half of the pond will be used to store pyrolysis cooling water, an estimated 303 m^3 (80,000 gal) of water produced by the pyrolysis process from the saline zone, plus 176 m^3 (20,000 gal) of leached zone water. Because of the relatively large amount of water involved in the last six days of the pyrolysis process, there may be insufficient time for complete separation of the oil and water in the oil-water storage tank. If this occurs, it will be necessary to temporarily release the oil and water mixture into the holding pond. This oil would be pumped back to the storage tank by a skimmer after separation.

The holding pond will be lined with an impermeable man-made liner. Under normal conditions no leakage or other accidental discharge will occur. However, if a leak or spill of the leachate from the pond would occur, it would flow either as surface runoff down-slope and into Horse Draw or infiltrate the bedrock and alluvium, gradually reach the water table of the upper aquifer. Normally a surface spill would infiltrate the highly fractured bedrock without moving a very great distance down-slope and into Horse Draw. Horse Draw is an ephemeral stream; therefore, the only conceivable method for a spill to reach

Piceance Creek as surface flow would be during times when Horse Draw is discharging into Piceance Creek. A conservative worst case analysis to estimate the effects of this event is the comparison of mean annual flow of Piceance Creek to the instantaneous placement of the full volume of the pond into Piceance Creek. The mean daily flow of Piceance Creek is about 14,180 cubic hectometers (1.15 x 10^7 gal - 35.2 ac-ft/day) at its confluence with Ryan Gulch about 1.6 km (1 mi) south of the project site. The total volume of the pond, 1,892 m^3 (500,000 gal). represents only 4 percent of one day of the average runoff. The spill would be diluted by runoff and would not significantly affect surface water quality.

A spill or leak from the pond would move vertically and horizontally through the bedrock, eventually reaching the water table of the upper aquifer located about 46 m (150 ft) below ground surface. Once reaching the water table the leachate would follow the hydraulic gradient. The local hydraulic gradient is towards Piceance Creek which receives recharge from the upper and lower aquifers. Using the geohydrologic test data for hole 02A on the upper aquifer (Dale and Weeks, 1978) and the upper aquifer thickness at Pilot Hole "X" the rate of ground water movement is approximately 14 m/yr (47 ft/yr). This corresponds to similar rates of movement from other studies in the region (Fox, 1979). The equation used for this analysis is:

$$\text{rate of ground water movement} = \frac{\text{hydraulic conductivity x hydraulic gradient}}{\text{porosity}}$$

$$\text{hydraulic conductivity} = \frac{\text{transmissivity}}{\text{aquifer thickness}}$$

$$= \frac{2{,}600\ \text{ft}^2/\text{day}}{940} = 2.77\ \text{ft/day}$$

hydraulic gradient = 50 ft/mile (Weeks, et al., 1974)

porosity is assumed to be 20%

This analysis assumes leachate movement through the interstitial portions of the bedrock and not along any fracture system. The rate of movement through interconnected fractures is expected to be faster. However, the extent of such a fracture system and data on the rate of movement are unknown and therefore were not analyzed.

Based on this analysis it is estimated that it would require about 111 years for leachate escaping from the pond to reach Piceance Creek and the one well located at T1S, R97W Section 28 (see Figure 4.6-2). The well located at T1S, R97W, Section 32 is up gradient from the pond, and would not be affected.

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$$\text{rate of ground water movement} = \frac{\text{hydraulic conductivity} \times \text{hydraulic gradient}}{\text{porosity}}$$

$$\text{hydraulic conductivity} = \frac{\text{transmissivity}}{\text{aquifer thickness}}$$

$$= \frac{2{,}500 \text{ ft}^2/\text{day}}{900} = 2.77 \text{ ft/day}$$

hydraulic gradient = 50 ft/mile (Weeks, et al., 1974)

porosity is assumed to be 20%

This analysis assumes leachate movement through the interstitial portions of the bedrock and not along any fracture system. The rate of movement through interconnected fractures is expected to be faster. However, the extent of such a fracture system and data on the rate of movement are unknown and therefore were not analyzed.

Based on this analysis it is estimated that it would require about 111 years for leachate escaping from the pond to reach Piceance Creek and the one well located at T1S, R97W Section 36 (see Figure 4.4-2). The well located at T1S, R97W, Section 32 is up gradient from the pond, and would not be affected.

The impact of a spill or leak on water quality would be greatest in the immediate area of the pond and the leachate would gradually be diluted by other ground water in the aquifer as it moves down gradient away from the pond. In addition, certain constituents of the leachate would be adsorbed as the water passes through the host rock. Local ground water quality would be somewhat affected by such infiltration, but the regional effect on ground water and surface water would be insignificant.

Period of Evaporation of Holding Pond Water

The holding pond has a total surface area of approximately 13.4 km^2 (44,000 ft^2). One-half of this pond will contain 189 m^3 (100,000 gal) of pyrolysis cooling water. The other one-half will hold approximately 1,514 m^3 (400,000 gal) of leach water and carbon recovery cooling water. The rate of evaporation from these ponds will depend on the climatic conditions such as the amount of precipitation, air movement, air temperature and time of year, due to seasonal variations.

The only inflow to the pond after completion of the mining process is precipitation, which averages approximately 0.3 m (11 in) at Meeker, about 35 km (22 mi) east of the project site. Therefore, the water level of the pond will decrease with time as the water evaporates. The average evaporation for 1978 and 1979 at the Oil Shale Tract C-b about 13 km (8 mi) from the project site, was approximately 4.2 mm (.165 in) per day during the months of May through September 0.6m/year (25 in). Due to freezing weather, only a minimal amount of evaporation occurs during the rest of the year. The time required to evaporate water from the pond depends upon the time of year it is filled and abandoned. This is currently unknown, so use of the average annual rate of evaporation and precipitation will provide an estimate of the maximum time required. The approximate annual evaporation is 0.6 m (25 in) and average annual precipitation is 0.3 m (11 in). With these climatic conditions the pond containing pyrolysis cooling water would dry up in about 6 months and the pond containing leachate would dry up in about 2 years.

The least amount of time required for evaporation of each pond (assuming no precipitation and a continuous evaporation rate of 4.2 mm (.165 in) is 44 days for the pond holding pyrolysis cooling water and 176 days for the pond holding leach water and carbon recovery cooling water.

From this analysis, it is evident that the volume of potential leakage or spillage from the ponds would decrease with time, due to the gradual loss of water to evaporation.

Holding Pond Monitoring Program

The holding pond may be monitored to determine if it is leaking. This would require a staff gage to measure water levels on each side of the

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Period of Evaporation of Holding Pond Water

The holding pond has a total surface area of approximately 13.4 km² (44,000 ft²). One-half of this pond will contain 458 m³ (120,000 gal) of pyrolysis cooling water. The other one-half will hold approximately 1,514 m³ (400,000 gal) of leach water and carbon recovery cooling water. The rate of evaporation from these ponds will depend on the climatic conditions such as the amount of precipitation, air movement, air temperature and time of year, due to seasonal variations.

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The least amount of time required for evaporation of each pond assuming no precipitation and a continuous evaporation rate of 4.2 mm (.165 in) is 46 days for the pond holding pyrolysis cooling water and 176 days for the pond holding leach water and carbon recovery cooling water.

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Holding Pond Monitoring Program

The holding pond may be monitored to determine if it is leaking. This would require a staff gage to measure water levels on each side of the

pond, measurement of water pumped into and out of the ponds, and measurement of precipitation. The rate of evaporation could be obtained from a pan evaporation station in the general area. A water balance can be determined when these parameters are known and could use the following equation:

sum of inflow = sum of outflow; or
pumped in + precipitation = pumped out + evaporation

If the amount of outflow is significantly greater than the amount of inflow the reason may be assumed to be a leak in the pond. The appropriate mitigation measures would be to patch the pond or replace the liner to prevent further leakage.

5.7 Land Use

5.7.1 Project Site Land Uses

Land uses on the USBM tract include livestock grazing, wildlife habitat, recreation, and mining. The primary adverse impacts on the USBM tract are expected to be a minor decrease in animal units of forage, potential hazard to human and livestock safety, temporary disruption of the landscape, and potential land use conflicts between USBM and other energy and mineral recovery efforts. Recreation is expected to be beneficially affected.

The impact of disturbance on the landscape is expected to be minor. Approximately 9 ha (22 acres) of land have been disturbed resulting in the removal of 2 animal units of forage. Such disturbance includes an improved road from County Road 5 to the Research Facilities Site (approximately 3 km or 2 mi), 2 drill pads and the holding pond.

Livestock Grazing

Approximately 9 ha (22 ac) of land have been disturbed and removed from forage production. No further surface disturbance is expected. The BLM's Environmental Analysis Report prepared in 1976 for the larger scale proposed project reported that disturbance of 105 ha (260 ac) would result in a loss of approximately 20 animal units of forage. Thus, disturbance of 9 ha (22 ac) is expected to result in a loss of approximately 2 animal units of forage. Most forage production occurs on the chained area of Pasture F and no surface disturbance has occurred there. Due to these factors, forage production for domestic grazing will be insignificantly affected.

If the project is abandoned without proper reclamation and rehabilitation, forage potential on the 9 ha (22 ac) would be lost.

Recreation

The Research Facilities Site is located in Big Game Management Unit 22, one of the most productive BGMU's for mule deer in the state.

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Livestock Grazing

Approximately 9 ha (22 ac) of land have been disturbed and removed from forage production. No further surface disturbance is expected. The BLM's Environmental Analysis Report prepared in 1976 for the larger scale proposed project reported that disturbance of 100 ha (250 ac) would result in a loss of approximately 20 animal units of forage. Thus, disturbance of 9 ha (22 ac) is expected to result in a loss of approximately 2 animal units of forage. Most forage production occurs on the chained area of Pasture F and no surface disturbance has occurred there. Due to these factors, forage production for domestic grazing will be insignificantly affected.

If the project is abandoned without proper reclamation and rehabilitation, forage potential on the 9 ha (22 ac) would be lost.

Recreation

The Research Facilities Site is located in Big Game Management Unit 22, one of the most productive BGMU's for mule deer in the state.

Also, the site is located in Small Game Management Unit 22 in which a significant amount of hunting occurs for cottontail rabbit. Access to the area adjacent to the Research Facilities Site has been improved by USBM and will remain open to the public. For this reason, small and big game hunting opportunities should be beneficially affected.

Other recreation opportunities which occur in the area such as rockhounding and wildlife viewing should also be enhanced due to improved access.

USBM facilities such as the holding pond, mine shaft and headframe have been fenced and should not be a hazard to safety of curious recreationsts who wander on site.

Mining

The USBM tract overlaps existing oil and gas leases, portions of sodium lease application areas and a tract nominated by industry for in situ development of oil shale. According to the Intra-Agency Cooperative Research Agreement between BLM and USBM no other disposition of the mineral resources will be made by BLM without the concurrence of USBM. Thus, the USBM project could present a problem for other resource recovery efforts. However, due to the small size of the USBM project, other mineral and energy resource developments are not expected to be precluded.

5.7.2 Regional Land Use

Due to the small size of the USBM Oil Shale Research Project, the small number of employees, the small area to be disturbed, and the type of activities planned to occur on-site, off-site adverse impacts are not expected to occur as a direct result of the MMC Project. Potential impacts associated with the small increase in population may be reflected in increased resident participation in recreation activities, increased demand for services (see 5.8 Socioeconomics), and increased demand for new housing. These potential impacts cannot be quantified. However, an adequate supply of recreation areas and activities exists in the study area, although housing may be a problem for employees until some of the anticipated units are constructed.

5.7.3 Land Use Plans

Major impacts of the project on land use plans, controls and constraints are not anticipated. A Memorandum of Agreement has been settled between Rio Blanco County and the BLM as well as a BLM/USBM Cooperative Research Agreement. These documents control impacts such as improper disposal of mine and sanitary wastes, improper care of spoils piles and associated run-off, improper storage and disposal of mined material from drifts, and air contamination. USBM has complied with both agreements and applicable County regulations and no significant impacts have resulted. It is anticipated that all applicable requirements will be met in the future.

5.8 Socioeconomics

Socioeconomic impacts associated with the proposed project are not expected to be major. Most potential impacts will be associated with increased population. Due to the proximity of Meeker (in Rio Blanco County) and Rifle (in Garfield County) to the Research Facilities Site, USBM induced population could all reside in Meeker, all in Rifle, or could be distributed among the two communities. Several factors will contribute to an individual's decision about where to live: 1) distance from the job site; 2) availability of services, and 3) availability of housing. Meeker is slightly closer to the USBM site but services and housing are rapidly reaching a premium. Rifle is slightly further, but services and housing more readily available.

The maximum number of employees to be working at the site at one time will be 50, with 9 in administration and 41 in construction. The construction employees will not all be working for the full 6 months of construction time. Additional employment information is preseted in Table 5.8-1.

Because the increased population will be relatively small, it would be highly speculative and serve little purpose to project population distribution between Rifle and Meeker. Thus, it will be assumed that all new USBM employee-residents, families, and associated secondary service employment will reside in either Meeker or Rifle; maximum impacts will be estimated for both towns.

All socioeconomic multipliers used to calculate impacts and the sources of those multipliers are provided by subject in Appendix G.

The primary socioeconomic impacts on the town of Meeker are expected to be a slight increase in population, a shortage of housing, additional students in Meeker's overcrowded kindergarten and elementary schools, and additional increased demand on Meeker's wastewater treatment and solid waste disposal capacities. The basic economy of Meeker should be beneficially affected by revenues generated from employee incomes.

If all project employees reside in Rifle, the main impacts are expected to be a shortage of housing and possibly overcrowding in the school system. Rangely would also be effected by this project, the main impact being economic. Rangely will benefit from the increase in property and sales taxes collected by the county. Should some employees chose to live in Rangely, housing availability is anticipated to be a problem, however, the schools are capable of handling additional students.

5.8.1 Population

Recent information suggests that population has increased in the last year to well over 2,300 persons (CWACOG, 1980). Thus, the 1,848 base

TABLE 5.8-1

PROJECT EMPLOYMENT AND ORGANIZATION

Type of Personnel	Number	Length of Employment
Administration	9	12 months
Construction	41	6 months
Process Testing	17	3 months
Demobilization	20	3 months

Note: These numbers are not cumulative. The maximum employment at any one time will be 50 people.

Source: Processing Research Program - Final Draft, Multi Mineral Corporation, November 29, 1979.

population figure from the 1977 Census probably does not reflect the existing situation. However, since no other figures have been produced in existing literature, it is assumed that base population is 1,848. Furthermore, because impacts discussed below are based on this base population figure, they should be viewed as conservative estimates.

The total number of employees for the project will be 87, as seen in Table 5.8-1. However, all employment capabilities are unique, and the only employees who will be present for the entire 12 month job will be the 9 people in administration. The maximum number of employees at any one time will be 50. All construction personnel will be specialized, and many tasks will not take the full 6 months designated for construction.

If a "worst case" situation is assumed and all USBM employees are new residents in the area and they all decide to reside in Meeker, population could increase by approximately 225 to 2,073 (NOTE: A total induced population multiplier of 4.5, which includes direct induced popuation [2.0] and indirect service population [2.5] was used [see Appendix G]). Of the 225 people generated, 100 will be basic employment related, 50 employees of Multi Mineral and 50 family members. It must be noted, however, that some new resident-employees will be transient or without families. The additional 125 people result from service related employment. Using an indirect service employment multiplier (0.7) (see Appendix G), 35 will be employed in the service sector, and 90 will be family members.

In 1977 the population of Rifle was reported to be 2,244. Recent observations of growth in Rifle indicate that population has increased markedly since the 1977 Special Census, perhaps to more than 3,800 (Johnson, pers. comm., 1980). Thus, the 1977 population of 2,244 probably does not reflect the real situation. However, no other figures have been produced in existing literature because census counts cannot keep pace with the growth occurring in Rifle. Thus, it must be assumed that base population is 2,244. Further, because impact projections are based on this base population figure they should be viewed as conservative.

Based on the same assumptions made for Meeker projections, if the 50 USBM new resident-employees and their families decide to reside in Rifle, population could increase by 225 to 2,469 people. (NOTE: The same population multiplier of 4.5 used for Meeker calculations was used for the Rifle.)

5.8.2 Housing

As indicated in Section 4.0, little or no surplus housing is presently available in Meeker. However, many units are under construction, and approximately 5,000 are now in the planning stages (Edwards, pers. comm., 1980). If all new resident-employees or the population equivalent of 225 persons decide to reside in Meeker, housing availability could present a problem if no vacancies are available and if pending

population figure from the 1977 Census probably does not reflect the existing situation. However, since no other figures have been produced in existing literature, it is assumed that base population is 1,048. Furthermore, because impacts discussed below are based on this base population figure, they should be viewed as conservative estimates.

The total number of employees for the project will be 67, as seen in Table 5.8-1. However, all employment capabilities are unique, and the only employees who will be present for the entire 12 months will be the 9 people in administration. The maximum number of employees at any one time will be 50. All construction personnel will be specialized, and many tasks will not take the full 9 months designated for construction.

If a "worst case" situation is assumed and all USGM employees are new residents in the area and they will decide to reside in Meeker, population could increase by approximately 225 to 1,273. (NOTE: A total induced population multiplier of 4.5, which includes direct induced population [2.0] and indirect service population [2.5] was used [see Appendix G]). Of the 225 people generated, 100 will be basic employment related, 50 employees of Multi Mineral and 50 family members. It must be noted, however, that some new resident-employees will be transients or without families. The additional 125 people result from service related employment. Using an indirect service employment multiplier (0.7) (see Appendix G), 35 will be employed in the service sector, and 90 will be family members.

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development proposals are not completed in the near future. If only one-half of the new resident-employees, or 113 people, move to Meeker, housing will be less of a problem but a shortage may still exist. It is expected that competition for housing will be acute due to rapid population growth which is currently occurring as a result of other numerous large energy development projects in the area (Rehborg, pers. comm., 1978).

In the last three years Rifle has increased its housing stock by 50 percent. This trend is expected to continue until development pressures ease. Housing is currently keeping pace with demand.

5.8.3 Community Services

Education Facilities

Meeker's elementary schools are currently operating at capacity. Applying a .15 multiplier (see Appendix G) to USBM induced population of approximately 225, an increase of approximately 34 students could result. Thus Meeker's elementary schools could be adversely impacted.

Meeker's new junior high school is operating at about half of its 250 student capacity, and the intermediate school is capable of accommodating 150 students. Using a factor of 4.5 percent junior high school students per total population increase, or a .05 multiplier (see Appendix G), potential USBM induced population increases will result in an increase of about 11 students. Thus, no adverse impacts are expected to Meeker's intermediate and junior high school.

The senior high school is also operating at about half of its 450 student capacity. If a multiplier of .06 high school students per total population (see Appendix G) is applied to USBM total induced population, approximately 13 high school students will be added to the senior high school. Thus, no adverse impact is expected.

Rifle's schools are operating at capacity according to the School District Office (1980). If the same percentages used in the Meeker calculations (i.e., 15 percent elementary/total poulation, 4.5 percent junior high school/ total population, and 6 percent senior high school students/total population) are applied to Rifle, Rifle can expect USBM induced school enrollment increases of approximately 34 new elementary students, 41 junior high students, and 13 senior high students. This could have an adverse impact on the schools until the new facilities, which are planned, are in operation.

Health Care

Medical and health care facilities in Meeker should be adequate to accommodate the USBM induced population increase of 42 to 84 people. Using a 1.0/1,000 population multiplier for the number of doctors (see Appendix G) needed in a community and assuming the population of

development proposals are not completed in the near future. If only one-half of the new resident-employees, or 111 people, move to Meeker, housing will be less of a problem but a shortage may still exist. It is expected that competition for housing will be keen due to rapid population growth which is currently occurring as a result of other numerous large energy development projects in the area (Ramborg, pers. comm., 1978).

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Meeker's new junior high school is operating at about half of its 250 student capacity, and the intermediate school is capable of accommodating 100 students. Using a factor of 4.5 percent junior high school students per total population increase, or a .05 multiplier (see Appendix G), potential USRM induced population increases will result in an increase of about 10 students. Thus, no adverse impacts are expected to Meeker's intermediate and junior high school.

The senior high school is also operating at about half of its 400 student capacity. If a multiplier of .06 high school students per total population (see Appendix G) is applied to USRM cases induced population, approximately 13 high school students will be added to the senior high school. Thus, no adverse impact is expected.

Rifle's schools are operating at capacity according to the School District Office (1980). If the same percentages used in the Meeker calculations (i.e., 15 percent elementary/total population, 4.5 percent junior high school/ total population, and 6 percent senior high school students/total population) are applied to Rifle, Rifle can expect USRM induced school enrollment increases of approximately 34 new elementary students, 41 junior high students, and 13 senior high students. This could have an adverse impact on the schools until the new facilities, which are planned, are in operation.

Health Care

Medical and health care facilities in Meeker should be adequate to accommodate the USRM induced population increase of 93 to 84 people. Using a 1.0/1,000 population multiplier for the number of doctors (see Appendix G) needed in a community and assuming the population of

Meeker will increase by 42 to 1,890, approximately 2 doctors would be required to serve the new population level of 1,890. Similarly, if population increased by the worst case figure of 225, 2 doctors would be required. Since Meeker has 2 doctors, there should be no impact. Using a .65/1,000 population multiplier for dentists (see Appendix G), approximately 1 dentist would be required. Since Meeker has 1 dentist, there should be no impact except that Meeker's dentist may be in greater demand.

The Pioneer Hospital in Meeker employs 15 full-time professional staff including 10 Registered Nurses (RN) and 3 Licensed Practical Nurses (LPN). Assuming 5 nurses would be needed per 1,000 population (see Appendix G), approximately 9 to 10 nurses would be required to serve a population of 1,890 to 1,932. Thus, it appears as though Meeker's hospital employs adequate professional staff to accommodate this small growth increment. Pioneer Hospital is a 17-bed facility. It is believed that adequate facilities exist to serve the current population and the projected additional 225 persons.

As reported in Section 4.0, 4 doctors and 3 dentists have practices in Rifle. The hosipital employs approximately 20 nurses, both RN's and LPN's. Applying the same multipliers used in the Meeker analysis (see Appendix G) to the USBM induced projected population levels of 2,286 and 2,328, Rifle would require about 2 doctors, 2 dentists, and 11 to 12 nurses. Rifle's current medical staff is more than adequate to serve the USBM induced projected population level. Thus, no measurable adverse impact is expected.

Police and Fire Protection

Meeker's existing police and fire protection capabilities are not expected to be measurably affected by USBM induced population increases.

Meeker currently employs 4 policemen and 1 chief. If it is assumed that 2 police personnel are required to serve a 1,000 population, approximately 4 personnel would be required to serve the new total population level of 2,073 (see Appendix G). The police department has 2 vehicles. If .5 vehicles per 1,000 population are required, Meeker has adequate vehicles to serve the projected population (see Appendix G).

Similarly, Meeker's fire department has a total volunteer/permanent personnel capability of 35 firefighters. Using the same multiplier applied to police personnel, at the projected population level, 4 firemen would be required (see Appendix G). Thus, adequate personnel should exist to serve the additional USBM induced population increases.

Meeker's fire department has a total of 5 vehicles. Using multipliers of .5 pumpers per 1,000 population applied to the projected population

level of 2,073. Meeker would require at least 1 pumper truck to serve the projected population (see Appendix G). Thus, it appears that the Meeker fire department is adequately equipped to serve the projected population.

Rifle's police protection capability consists of 10 policemen, 1 chief and 3 vehicles. The department is supplemented by assistance from the Garfield County Sheriff's Office and the Colorado Highway Patrol.

Applying the same multipliers for Meeker (see Appendix G) to the anticipated population level of 2,469 resulting from MMC induced increases, Rifle will require 11 personnel and about 1 vehicle to serve the new population levels. Thus, no adverse impact on Rifle's existing police protection capacity is expected.

It has been reported that since mid 1977, crime in Rifle has doubled due to population increases (Merkle, pers. comm., 1978). Multi Mineral generated population increases of approximately 225 persons should not significantly contribute to increases in crime. This impact cannot be quantified with existing data.

It was reported in Section 4.0 that Rifle's fire department is currently all volunteer and utilizes 3 pumpers, a 6x6 army surplus troop carrier, 1 equipment truck and 1 ambulance. Existing personnel total approximately 35. No service problems are expected (Merkle, pers. comm., 1978).

In addition, existing data regarding vehicles are insufficient to determine vehicle needs associated with the population increase. Again, no measurable adverse impact on fire protection service is expected.

5.8.4 Utilities

Meeker

Water Supply

As reported in Section 4.8, Meeker's water supply system has the capacity to serve a population of 4,000 persons. The projected maximum population increase should have no adverse effect on the existing water supply.

Telephone, Gas, Electricity

White River Electric Association, the Western Slope Gas Company, and Mountain Bell all have adequate capabilities to provide service to a population increase of 225.

level of 2,073. Meeker would require at least 1 pumper truck to serve the projected population (see Appendix G). Thus, it appears that the Meeker fire department is adequately equipped to serve the projected population.

Rifle's police protection capability consists of 10 policemen, 1 chief and 3 vehicles. The department is supplemented by assistance from the Garfield County Sheriff's Office and the Colorado Highway Patrol.

Applying the same multipliers for Meeker (see Appendix G) to the calculated population level of 2,465 resulting from 255 induced increases, Rifle will require 11 personnel and about 1 vehicle to serve the new population levels. Thus, no adverse impact on Rifle's existing police protection capacity is expected.

It has been reported that since mid 1977, crime in Rifle has doubled due to population increases (Harris, pers. comm., 1978). Multi Mineral generated population increases of approximately 255 persons should not significantly contribute to increases in crime. This impact cannot be quantified with existing data.

It was reported in Section 4.0 that Rifle's fire department is currently all volunteer and utilizes 2 pumpers, 1 5x5 army surplus troop carrier, 1 equipment truck and 1 ambulance. Existing personnel total approximately 35. No service problems are expected (Harris, pers. comm., 1978).

In addition, existing data regarding vehicles are insufficient to determine vehicle needs associated with the population increase. Again, no measurable adverse impact on fire protection service is expected.

5.8.4 Utilities

Meeker

Water Supply

As reported in Section 4.8, Meeker's water supply system has the capacity to serve a population of 4,000 persons. The projected maximum population increase would have no adverse effect on the existing water supply.

Telephone, Gas, Electricity

White River Electric Association, the Western Slope Gas Company, and Mountain Bell all have adequate capabilities to provide service to a population increase of 255.

Wastewater Treatment

Meeker's wastewater treatment system was reported to be designed to serve a population of at least 4,000. Based on the 1977 reported population level of 1,848 and the projected USBM increase to 2,073, there should be adequate capacity to accommodate USBM induced growth. However, recent information obtained from the County Planner and the County Engineer indicates that Meeker's population has increased to 2,300 since the Special Census in 1977 (Johnson, pers. comm., 1980). Also, the existing capacity of the wastewater treatment facility is committed (Rehborg, pers. comm., 1978). Although there should be adequate capacity to serve the USBM increase, USBM induced population will contribute to a small percentage increase in cumulative demand on total capacity of the facility, until Meeker proceeds with its approved plans and funding for expansion.

Solid Waste Disposal

The solid waste disposal site used by Meeker and the county has recently been expanded. Solid waste generated from the USBM project and project induced population should have no adverse impacts.

Rifle

Water Supply

Rifle's water supply currently has the capacity to serve a population in excess of 4,000 (Merkle, pers. comm., 1978). If Rifle's population increases by 225, adequate water supplies should exist. Thus, no measurable adverse impact is expected.

Wastewater Treatment

Rifle's wastewater treatment system is expected to be operating at capacity within the next two years. With addition of the new expansion, a total population of 10,000 could be served. Thus, with or without the new expansion, adequate capacities exist to accommodate USBM induced population.

Solid Waste Disposal

The Garfield County/Rifle Sanitary Landfill has two existing trenches. One was reported in Section 4.8 to be nearly full. A new trench has been opened and additional space is available for new trenches as needed. Thus, MMC induced population will have no measurable adverse impact on solid waste disposal capacity.

Telephone, Gas, Electricity

White River Electric Association, Western Slope Gas Company, and Mountain Bell all have adequate capacities to serve the MMC induced population increase in Rifle.

5.8.5 Economics

All socioeconomic multipliers used to calculate impacts and the sources of those multipliers are provided by subject in Appendix G.

Employment and Income

Multi Mineral expects maximum employment to be 50 employees during construction and about 20 to 30 during operation phases of the project. USBM is currently drawing very little of its total work force from local labor pools due to the low unemployment rate. It is anticipated that this trend will continue through the research phase of the project. Thus, it is assumed that all new employees will be hired from outside the region. In addition, using a .7 secondary service employment multiplier (see Appendix G), 35 new jobs should be created as a result of the 50 new resident-employees expected to move in to the county.

Local income should increase due to infusion of project investments into the local economy. Income will be distributed through local wage payment and purchases of goods and services. Project employee income is projected to total $191,553. Purchases anticipated in Rio Blanco County total $315,000, which would increase local merchant revenue and generate more sales tax revenue.

Financial Resources

Financial resources of Meeker and Rifle should be enhanced through collection of local property taxes levied on homes purchased by Multi Mineral employees and associated secondary service employees, collection of sales tax on employee purchased goods and services and Multi Mineral purchased goods and services.

County Finances

The USBM project is exempt from state and local taxes because it is federally owned and operated. However, all improvements made to the project site by Multi Mineral Corporation will be subject to a corporate property tax to be collected by the county. The primary adverse impact on Rio Blanco County associated with the USBM project is expected to be uncaptured potential property tax revenues on the land. Concurrently, USBM is utilizing county services such as road maintenance on County Road 5, fire and police services, and emergency health services provided by Pioneer Hospital in Meeker. Additional revenues may be lost if USBM employees decide to live outside the county in Rifle. However, county and municipal services will not have to be provided to those employees. Some county revenues will be captured through property taxes on homes purchased in the county by USBM employees, and Multi Mineral anticipates improvements valued at $1,836,000 which will add to county funds.

5.8.6 Community Attitudes

All three communities in the study area are projected to receive substantial population increases from proposed energy developments in the region. Projected population levels for the communities are given in Table 5.8-2. Increased population will place demands on existing community services and facilities. Abilities of communities to prepare for growth will depend on adequate knowledge of projected population increases and sufficient funds to cover the costs of expanding and improving facilities.

Quality of life of residents is anticipated to be affected by cumulative population increases projected for the area. The severity of these impacts to the quality of life will be determined by a number of factors, including availability of housing; adequate community services, e.g., police and fire protection, utilities, health care, education facilities; social acceptance of new residents by long-term residents, etc.

5.8.7 Cumulative Effects

Anticipated changes within the study area are well documented in numerous environmental impact statements and reports prepared in recent years for various energy development projects in the area. Among those documents are the following: The Northwest Coal EIS; the Draft EIS relating to oil shale development by Colony Development Corporation; Final Environmental Impact Statement for the Prototype Oil Shale Leasing Program by the BLM; several environmental impact analyses published by Thorne Ecological Institute; Impact Analysis and Development Patterns Related to the Oil Shale Industry by THK Associates, Inc., and Draft EIS Proposed Superior Oil Company Land Exchange and Oil Shale Resource Development, BLM.

This is meant to be a brief summary of other energy projects in the project area, and an acknowledgement of the impacts which could result due to the combined projects.

Table 5.8-2 shows projects by other agencies and private companies which would contribute to the impacts in the study area. This table outlines project area, major activity, long range productions, and approximate number of employees on-site at present and at peak production. There are eight oil shale projects listed, which could result in approximately 9,000 employees by 1985. These projects will have different peak periods, however, which should help to minimize the impacts. Coal projects have also been included on the table, but very little information is available on employee numbers and production levels.

The impacts produced in the study area by these additional projects are basically the same type as for the proposed project. However, the magnitude of impacts from these projects would be greater.

TABLE 5.8-2

ENERGY PROJECTS WHICH MAY CONTRIBUTE TO CUMULATIVE IMPACTS DURING MULTI MINERAL RESEARCH

Project	County	Mineral	Long-Range Production	Present Number of Employees	Anticipated Employees & Date of Peak Production
Federal Tract Ca. - Rio Blanco Oil Shale Project	Rio Blanco	oil shale	76,000 bbl/day	275	1,800 - 1979
Federal Tract Cb. - Occidental Oil	Rio Blanco	oil shale	100,000 bbl/day	275	2,100 - 1981
Superior Oil	Rio Blanco	oil shale	11,880 bbl/day		
		nahcolite	6,097 tons/day	Unknown	1,300 - 1982
		alumina	630 tons/day		
		soda ash	1,228 tons/day		
Rangely Oil Field - Chevron	Rio Blanco	oil	57,000 bbl/day	Unknown	Unknwon
Equity Oil Co.	Rio Blanco	oil shale	Unknown	6	45
Chevron Oil	Garfield	oil shale	100,000 bb/lday	Unknown	Unknown
Colony	Garfield	oil shale	45,000 bbl/day	Unknown	Unknown
Union Oil Co.	Garfield	oil shale	100,000 bbl/day	150	Unknown - 1995
Paraho Oil Shale Development	Garfield	oil shale	12,000 bbl/day	175	300 - 1983
Colywo Coal Co.	Moffat	coal	1,675,000 tons/yr	373	485
Consolidation Coal Co.	Rio Blanco	coal	Unknown	Unknown	Unknown
Midland Coal Co.	Rio Blanco	coal	Unknown	Unknown	Unknown
Northern Coal Co.	Rio Blanco	coal	Unknown	83	362 - 1985
Allen D. Gray	Rio Blanco	coal	800,000 tons/yr	75	85 - 1980
Paul S. Coupey	Moffat	coal	Unknown	Unknown	Unknown

Source: Colorado West Area Council of Governments, 1980. Oil Shale Trust Fund Request.

Without the USBM project, growth will continue in Rio Blanco County and the towns of Rangely, Meeker, and Rifle as a result of other mineral and energy resource developments. Increased demands will be placed on land for residential, commercial, industrial, and recreational uses.

Oil shale and coal developments will result in site-specific conversions of land from grazing, wildlife habitat, and recreation to more intensive industrial uses.

Increases in population generated by other mineral and energy resource developments will result in increased residential, commercial, and industrial development within and around Rangely, Meeker, and Rifle (Garfield County). Lands will be converted from agricultural uses, wildlife habitat and other open space uses to these more intensive uses. Pressure on recreation resources throughout the study area will also increase, resulting in more sight-seers, hunters, fishermen, and campers.

Housing requirements will fluctuate until approximately 1990 when demand will stabilize as shown in Table 5.8-3. Major impacts shown are during 1984 and 1985 when the present energy projects will have the highest number of employees. Inflation could easily result from housing demand exceeding supply until the market reaches its stabilization point. The possiblity of sprawl will increase as pressure for more housing units occurs.

Meeker, Rangely and Rifle have planned for anticipated growth, unlike many energy development boom towns in the past. Rangely has a Master Plan with which to pattern development. Meeker and Rifle both have Development Guides adopted especially for the influx of development. Some of the cities have utilities near capacity, but those that are also have expansion planned. Some schools will be impacted but expansion is also planned in areas where it is needed.

Higher per capita income will result from the projects in the study area and as a result the local economy could become inflated. Business activity will increase as a result of population growth. This would have a negative effect on households with fixed incomes who might eventually have to migrate out.

Due to the large difference between basic and non-basic employment, people may be lured out of service jobs. A void could be created in the service sector of the economy due to the low unemployment rate, and the pull of high paying jobs in the energy development field.

The oil shale, coal and gas industry will provide upper mobility for people presently in lower paying jobs. It will increase the per capita income and therefore the standard of living for households in the study area. However, the projects will also inflate the costs

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TABLE 5.8-3

PROJECTED NEW HOUSING REQUIREMENTS
FOR RIFLE, RANGELY AND MEEKER WITH THE
PROPOSED MULTI MINERAL AND INTERRELATED PROJECTS

Year	Rifle	Rangely	Meeker
1980	70	12	386
1981	264	381	273
1982	85	852	321
1983	80	39	150
1984	855	78	349
1985	109	22	532
1990	203	45	54
1995	204	44	58
2000	233	47	53
2010	407	93	107
Total	2,510	1,612	2,283

Source: Proposed Superior Oil Shale Company Land Exchange and Oil Shale Resource Development, BLM, 1979.

of goods and services in an area that presently has a relatively stable economy. They will also increase the demand on resources in the study area, including wildlife, land, water, means of transportation and services.

5.9 Transportation

The primary adverse impact on transportation networks anticipated in the study area is a slight increase in traffic on County Road 5, State Highway 64 between Meeker and County Road 5, and State Highway 13 between Rifle and County Road 5. Recent data on traffic volumes for County Road 5 are not available. Therefore, a percent increase in traffic cannot be calculated. It is anticipated that traffic will increase by about 40 vehicle trips or 20 vehicle round trips per day on these roads. This impact should be distributed between the three main access routes.

Traffic volume increases will probably result in increased deer road kills. This will have an effect on driver safety.

5.10 Aesthetics

Impacts to the visual resources in the project area have already occurred. However they are minimal. These impacts are limited to the Horse Draw vicinity (except for the access road) and are not evident from the road along Piceance Creek. Based on the BLM visual quality rating for the project area, any additional alterations to the existing landscape will not degrade a highly scenic or unique visual area.

5.11 Archaeology and Paleontology

5.11.1 Cultural Resources

Because development will be limited to the existing disturbed area, no known cultural resources will be directly impacted by the proposed project. There are numerous prehistoric sites in the USBM Tract. These may be adversely impacted by unauthorized collecting by project personnel and by possible future project activities outside the current development area.

5.11.2 Paleontological Resources

None of the known paleontological resources will be directly impacted by the proposed project; however, unknown subsurface resources may be encountered during mining. Also, known sites may be adversely impacted by unauthorized collecting by project personnel and by possible future project activities outside the current area proposed for development.

5.12 Energy Requirements

Implementation of the proposed action will entail an increase in energy consumption at the project site. Table 3.1-3 is an equipment list for the proposed action.

The utility section consists of two 2,000 kw diesel-driven electric generators, a 2,000 lb/hour low pressure oil fired boiler and a 600 SCFM diesel-drive air compressor.

Propane and diesel fuel are stored north and west of the process area in an area 326 m^2 (3,515 sq ft) surrounded by a 1.8 m (6 ft) high dike. Propane storage amounts to 83 m^3 (22,000 gal) or 5 days' processing requirements. Total propane consumption is approximately 476 m^3 (126,000 gal). Diesel storage of 60 m^3 (13,000 gal) is provided by the 4.5 m by 3.0 m (15 ft x 10 ft) tank. Diesel fuel consumption is expected to total 56 m^3 (15,000 gal).

Power requirements for pumps and equipment drivers are expected to peak at about 2,000 kw/hour and power is provided by the diesel-driven generators mentioned earlier.

Energy will be needed in other capacities. A sound-powered phone system will be used within the site. Butane and electric heaters are set up in the auxiliary buildings. Vehicles will need fuel to get to and from the project site.

Notwithstanding these higher levels of energy use, a balancing point is expected to be reached soon after the project begins. Although the main purpose of the proposed action is research, 1,000 barrels of oil are anticipated to be recovered from oil shale deposits during the 12 month project.

A positive outcome of the research effort will be to provide a viable and efficient means of recovering oil shale, which would more than compensate for the energy required to power the project.

5.13 Natural or Depletable Resource Requirements

Implementation of the proposed action will result in short-term effects on local natural resources. Natural or depletable resource use will be confined to a 12-month period and, as such, will be minor in overall consequence.

A total of 1,892 m^3 (500,000 gal) of water are required for processing. This is taken from the leached zone by pumping out of the core hole drilled during the Mining Research Program. This hole will be reworked to complete a water well in the leached zone.

The processing water is stored on the surface in the lined holding pond until it is needed. After its use in each processing step, the water is returned to storage awaiting the next step. When the final step is completed, 38 m^3 (10,000 gal) are transported off-site, 189 m^3 (50,000 gal) remain in the stope and 1,665 m^3 (440,000 gal) are retained in the surface holding pond for evaporation.

Water for utility usage such as showers, flushes, washdowns, etc., is supplied from an existing well equipped with a 250 gpm, 20 HP electrical motor and pump. A storage tank located in Storage Area 1 provides gravity flow to all outlets.

Potable water is brought to the site by designated workers on each shift. It is dispensed from insulated water coolers located near work centers.

Natural resources will also be appropriated to supply energy to the site. Details of the quantities of each fuel type and usage are presented in Section 5.12.

Construction and processing activities will create short-term adverse effects by raising the levels of noise and air pollution. Visual resources will be affected by the intrusion of equipment and drilling rigs. Biologic resources have already been affected by the surface grading needed to establish the project site.

5.14 Mitigation Measures

5.14.1 Measures Required by Federal Agencies

Several mitigation measures will be required of the USBM by the Bureau of Land Management. These include the following:

1. Bulk mine samples will be covered to prevent snow or rain from dissolving salts from the samples. Covering the stockpiles will reduce emissions of dust from them. In addition, a 30.5 cm (12 in) berm will be constructed around each stockpile. This measure will effectively prevent contact of precipitation with the stockpiles and will provide containment for a backup. The low berm will prevent runoff from outside from reaching the stockpile.

2. Any and all wastewater produced will be confined to the lined holding pond. This measure will diminish the possibility that saline ground water from bedrock aquifers would contact less mineralized surface water flows and shallow ground water.

5.14.2 USBM Committed Measures

The USBM has stated that it will perform the following mitigation measures:

1. Limit access to the Research Facilities Site by placing a gate on the access road. This will reduce potential hazard to human safety, shooting pressure on wildlife, and disturbance of wildlife by human activity.

2. Post signs warning of potential safety hazards around the USBM tract to prevent unauthorized access and reduce the risk of accidents.

3. The USBM will comply with written agreements with the USBLM.

4. The USBM will regrade and revegetate the project site following completion of research programs. This will restore some of the forage production, reduce sediment yield from the disturbed area, and restore the visual quality at the site.

5. No firearms will be allowed on site during any phase of project operations.

6. On the advice of the BLM and the Colorado Division of Wildlife, the USBM will aid in the improvement of a minimum of 50 acres of wildlife habitat to increase their suitability for deer utilization.

7. The USBM will aid employees in the formation of van or car pools.

8. Wells penetrating more than one aquifer will be cased and grouted. This will prevent movement of water between aquifers.

9. Performance of the lined holding pond will be monitored.

10. Solids remaining in the holding pond after evaporation will be either removed or covered with an impermeable seal to prevent potential leakage into the upper aquifer.

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SECTION 6.0

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SECTION 9.0

APPENDICES SUMMARY

Appendix A - Ecology

This reference consists of a summary of vegetation types in the project area, their structure and composition; stability, diversity and succession. Figures 1-4 indicate the ranges and habitats of mule deer, mountain lion, sage grouse, waterfowl and shorebirds. Also included is the Reclamation Plan for the research facility.

Appendix B - Air Quality

Referenced are the calculations and assumptions used to obtain air quality emissions estimates. Also included are tables regarding ambient air constituents and concentrations and air quality standards and emission control plans.

Appendix C - Geology and Soils

This appendix contains a soil chemistry table.

Appendix D - Surface Hydrology

The tables include information on mean daily discharges at various stations, balance and distribution of major ions at various stations, general water quality vs. discharge and suspended sediment concentration vs. discharge.

Appendix E - Ground Water Hydrology

Appendix E contains the following tables and figures: Ground Water Monitoring Wells Within and Near Study Area, Water Quality of the Alluvium, Water Quality of the Upper Aquifer and Water Quality of the Lower Aquifer.

Appendix F - Land Use

The following figures and tables are included in Appendix F: Land Status, Energy Resource Development Map and Recreation Supply-Demand Need Analysis.

Appendix G - Socioeconomics

The following tables are included: Employment Categories and Establishments, Family Income, County Revenues and Expenditures, and Socioeconomic Multipliers.

Appendix H - Aesthetics

Pictures of the various landscape units in the project area are included as well as a visual resource area map.

APPENDICES SUMMARY
(Continued)

Appendix I History, Archaeology and Paleontology

Ths section begins with a narrative on the history of the area. There is a table on prehistoric cultural resources, an archaeological reconnaissance of the Bureau of Mines site and a Paleontological Resources Inventory and Evaluation.